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COMITATO NAZIONALE ENERGIA NUCLEARE

CENTRO DI CALCOLO

PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES IN ITALY

for the period from Janury to December 1975

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PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES IN ITALY

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Compiled by
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1. C.N.E.N. - DIVISIONE DI FISICA - LABORATORIO DATI NUCLEARI - Via Mazzini, 2 - 40138 BOLOGNA (ITALY)

1.1. Evaluation of Fission Products

V. BENZI, F. FABBRI, E. MENAPACE, M. MOTTA, G.C. PANINI, G. REFFO, M. VACCARI

Complete evaluation and compilation in ENDF/B format, in the energy range 10^{-5} eV - 15 MeV, of the following isotopes: Mo-95,-97,-98,-100; Tc-99 ; Ru-101,-102,-103,-104; Rh-103 ; Pd-105,-107 ; Ag-109 ; Cs-133,-135 ; Pr-141 ; Nd-143,-145 ; Pm-147 ; Sm-149,-151 ; Eu-153. Each file contains resolved and mean resonance parameters, relevant cross sections (i.e. total, elastic, inelastic, n-2n, n-γ, n-p and n-α), angular and secondary energy distributions.

Purpose: Estimate of fast reactor long term reactivity changes.

Method: Calculations by BW-single and-multilevel formalism (resonance region) and by statistical and optical models.

Major sources of information: NEUDADA, CINDA.

Deadline of literature coverage: June 1975.

Cooperation: CEA: Cadarache and Saclay, RCN: Petten.

Other relevant details: 25 group cross sections at infinite dilution and 0°K temperature have been generated.

Computer file of compiled data : ENDF/B format.
Computer file of evaluated data

1.2. Multilevel Breit-Wigner Formalism

E. MENAPACE, M. MOTTA

Multilevel Breit-Wigner formulas which include analytical Doppler broadening of resonance cross-sections, have been developed. The analytical broadening is performed on the fission, capture and elastic cross sections through the well known ψ and χ functions. The presence of two only reaction channels (enter-exit) is assumed. Algebric signs for the reduced widths amplitude are also considered. A special Fortran IV code, PIUME, performs all the calculations

1.3. Radiative Capture of Fast Neutrons by Nuclei from Al to La

F. RIGAUD, M.G. DESTHUILLIERS and G.Y. PETIT
C.E.N.B.G., Gradignan, France

J.L. IRIGARAY
Université de Clermont-Ferrand, France

G. LONGO and F. SAPORETTI
C.N.E.N., Bologna, Italy

The radiative capture cross-section of 14.6 MeV neutrons by nuclei from Al to La has been measured by means of the activation method. The effect of secondary neutrons on the observed capture cross-section has been accurately taken into account by systematically varying the sample thickness and by minimizing the influence of the tritium target heads and of the target backing materials. The results of the present improved activation measurements indicate a value of about 10 ± 0.5 mb for the (n,γ) cross-sections in nuclei throughout the periodic table, which is in satisfactory agreement both with the results of spectrum method measurements and with the predictions of direct and semi-direct models.

1.4. Theoretical Estimates of (n,γ) Cross Sections for 6-15 MeV Neutrons

G. LONGO and F. SAPORETTI

The knowledge of the correct values of (n,γ) cross sections for high energy neutrons is of great interest for studies into nuclear reaction mechanism as well as for reactor shielding purposes and in particular fusion-reactor design. The use of theoretical estimates is therefore required to fill the gaps in the available experimental data. For this purpose the semi-direct capture model has been refined a) by replacing the previous surface form factors of the interaction by volume form factors, b) by including quadrupole terms in addition to the dipole ones. Calculations, based on the refined model, agree satisfactorily with experimental data.

(Calculations: (n,γ) cross sections; semi-direct model; complex interaction; volume form)

1.5. Statistical Properties of Experimental Sequences of Neutron Resonances

C. COCEVA and M. STEFANON

The extent to which experimental level sequences may follow the prediction of the statistical model based on G.O.E. hamiltonian matrices is studied theoretically by simulating, with a Montecarlo calculation, the experimental level sequences observed in s-wave neutron measurements in even even nuclei. This is accomplished by considering sequences of levels sampled from statistical model population but affected by missed s-wave and spurious p-wave neutron resonances. The aim of the study is to give general criteria about the significance of the experimental tests of the statistical model such as the value of the Δ_3 Mehta-Dyson statistic and about the possibility of estimating the average level spacing with the linear statistic which, for "pure" sequences, is affected by a very small variance.

1.6. Measurement of the Neutron Strength-Function of States with Specified Spin

C. COCEVA and P. GIACOBBE

At the Geel Linac, neutron capture γ-ray spectra from 95 to 425 keV were measured in nine adjacent neutron energy intervals selected by time of flight from 400 to 2000 eV. The intensities of certain γ-lines were used to determine in each time-of-flight interval the ratio of capture rates between $J=4$ and $J=3$ resonances, according to a method originally suggested by Pönitz [1] and by Coceva [2]. Average capture cross-sections were also measured in the same intervals.
Below 400 eV, the spin was assigned to 71 neutron resonances by application of the level population method. On the basis of the above measurements and of the known resonance parameters the neutron strength function was deduced separately for $J=4$ and $J=3$ states in the energy interval 0-2000 eV.

[1] W. Pönitz, Thesis, Karlsruhe (1966)

[2] C. Coceva, Int. School of Neutron Physics, Alushta (1974), Dubna D3-7991, p. 266.

1.7. High Energy Gamma Rays from ^{177}Hf Neutron Resonances

F. CORVI (°) and M. STEFANON

(°) CBNM, EURATOM, B-2440 GEEL, Belgium

Primary gamma transitions from thirty-eight ^{177}Hf neutron resonances were measured at the neutron time-of-flight facility of the Geel Linac. A 74% ^{177}Hf enriched target was used and twenty-nine γ intensities were measured, leading to final states with excitation energy up to 2050 keV. Electric and magnetic dipole reduced strengths were obtained; their average values are:

$$S_{E1} = \langle \Gamma_{\gamma y}/DE_{\gamma}^{5} \rangle A^{-8/3} = 4.9 \pm 1.0 \ 10^{-15} MeV^{-5}$$

$$K_{M1} = \langle \Gamma_{\gamma y}/DE_{\gamma}^{3} \rangle = 35 \pm 10 \ \ 10^{-9} \ MeV^{-3}$$

The ratio between E1 and M1 intensities is $r = 5{,}5 \pm 1{,}4$ in agreement with the systematic. A dependence of the transition strength on the K value of the final state is observed.

1.8. Programme for Shape-Analysis of Neutron Transmission Spectra

P. GIACOBBE, M. MAGNANI

A new programme has been written for analysing neutron transmission spectra in the region of resolved resonances. This programme has been conceived with the following characteristics.

1. It can take into account resolution functions of any shape, in particular asymmetric such as the one due to the moderation of the fast neutron burst produced by an accelerator.
2. It can exploit "a priori" information on resonance parameters given as constraints in the fitting procedure.

In its present state the programme fits transmission dips with single-level Breit-Wigner formulae. Doppler broadening is performed in the standard way, using the Ψ and Φ functions. The parametrisation of the B-W formula is given in Γ_n (or $2g\Gamma_n$) and Γ_γ, instead of σ_o and Γ, to avoid inconsistent solutions. However, the use of a particular reaction formalism is of minor importance, the aim being to introduce multilevel formalisms later.

The programme dimension, when up to 500 channels with no more than 10 resonances are analysed, is 320 K.

2. ISTITUTO DI FISICA DELL'UNIVERSITA' - Via Celoria, 16 - 20133 MILANO (ITALY)

2.1. A Statistical Approach to Scission Mechanism

U. FACCHINI [+] and G. SASSI

Istituto di Fisica dell'Università, Milano
[+] and CISE, Segrate (Milano)

A statistical model of scission mechanism is reported; the fission fragments are described as two spherical nuclei at given temperature and distance. The canonical formalism is introduced in order to describe the states of the system; the intrinsic freedom degrees, representing both the repartition of protons and neutrons in a given pair A_1, A_2 and the various possible configurations assumed by the excited nucleons are assumed in statistical equilibrium. The freedom degrees related to the collective motion of nucleons, which means to the fragment kinetic energies, are assumed not to be in statistical equilibrium. The partial equilibrium model has been applied to the calculations of fragment excitation energies and to the analysis of the fragment charge distributions.
U^{235}. fission induced by thermal neutrons and U^{233} fission induced by moderate energy protons have been analysed.

3. GRUPPO DI RICERCA I.N.F.N. IN FISICA DEL NUCLEO DELL'ISTITUTO DI FISICA NUCLEARE DELL'UNIVERSITA' - Via Taramelli, 4 - 27100 PAVIA (ITALY)

3.1. State of the ^{252}Cf nucleus at the scission point, as determined from the experimental results of ternary fission.

F. FOSSATI, T. PINELLI

The main purpose of the ternary fission analysis is to obtain information about the physical state of the nucleus in the last stage of normal binary fission. In particular the energy of the fragments at scission should be extremely important as a direct information about the dynamics of the process.

Starting from the features of the experimental results and using a new program, the following quantities have been calculated (1) at the scission point in the most probable mode of fission of ^{252}Cf.

a) Alpha-particles kinetic energy: the distribution evidences a concave shape with two maxima at about 0.5 and 4 MeV.

b) Position of the alpha-particle at emission: the coordinates of the light particle's emission point are rather broadly distributed around the point of minimum electrical potential. The results show that the majority of alpha-particles are released outside the fission axis and anywhere between the two fragments.

c) Angle of emission of the alpha particles: the distribution presents a doubly humped structure with two maxima at about 60° and 105° with respect to the flying direction of the light fragment.

d) Distance between fragment charge centres: this quantity ranges from 19 to 31 fm. with a broad distribution having a maximum at about 27 fm.

e) Kinetic energy of the fragments: the distribution ranging from 0 to 60 MeV is strongly peaked at about 50 MeV.

f) Asymptotic angular distribution: the gaussian fit gives a peak angle at 83° and a FWHM of 26°.

The calculated results described in the above items reproduce in a satisfactory way the experimental angle-energy correlations achieved up to now. Following the indications in the items a) b) c) d), a partial release of the alpha particles from the flying fragments has been assumed. On the basis of such an assumption, the alpha-particles energy of emission (E_α^x)

has been calculated in the rest system of the moving fragment. The obtained E_{α}^{x} distribution is shown in fig. 1 where a triple structure is evidenced. The first structure has been interpreted as concerning the ternary fission where the alpha-particles are released in conditions close to those pertaining to the normal binary fission.
In the same figure the mean values of other relevant quantities at scission point are shown in correspondence with the distinct structures. $\overline{D}_o$ and $\overline{E}_{F_o}$ indicate the quantity in the items d) and e) respectively.

3.2. Angular distribution of the alpha-particles in the fission of ^{226}Ra induced by 29-MeV protons

F. FOSSATI, T. PINELLI, F. ROBOTTI, V. ZOTTI

The purpose of the experiment is to study the configuration of the nucleus at the scission point in symmetric fission, in connection with the possibility of achieving indications about the eventual modification of the fission barrier in comparison with the low-energy asymmetric fission.
The angular distribution with respect to the single fragment and the energy spectra of the alpha particles relative to each analysed angle have been measured [2].
In table I the gaussian parameters of the obtained angular distribution are reported in comparison with previous results.
The energy spectra of long-range-alpha-particles are characterized by a noticeable decrease of the width (FWHM $\sim$ 7 MeV) and peak energy ($\sim$ 10 MeV).

TABLE I

Target	Ref.	Peak angle (Deg)	(Deg)
^{238}U+p	1	95	14.7
^{239}Pu	2	93±0.7	15.5±0.7
^{252}Cf	3	92	15
^{226}Ra	Present work	94±2	29±3

1. T.D. Thomas, S.L. Whetstone, Jr.: Phys. Rev. 144, 1060 (1966)

2. F. Fossati, C. Petronio, T. Pinelli: Nucl. Phys. A 208, 196 (1973)

3. G.M. Raisbeck, T.D. Thomas: Phys. Rev. 172, 1272 (1969)

Such unespected energy characteristics and the sensible enlargement of the angular distribution are interpreted in terms of a larger elongation of the nucleus in the symmetric scission configuration with respect to low-energy fission. In the above assumption the symmetric fission configuration appears with an increased nucleon quantity in the nuclear neck and a lower energy correlation in the structure of the fragments. Thus, as a consequence of the reduced shell effects, the fission barrier goes to approach, as energy increases, the shape of the liquid drop barrier which, in a very natural way, explains the symmetric mode of nuclear fission.

- F. Fossati, T. Pinelli: Geometrical and dynamical state of the ^{252}Cf nucleus at the scission point as determined from the experimental results of ternary fission - Nucl. Phys., A 249 (1975), 185.

- F. Fossati, T. Pinelli, F. Robotti, V. Zotti: Scission point in symmetric fission. Information from long-range alpha-particles - Il Nuovo Cimento, in press.

4. ISTITUTO DI FISICA DELL'UNIVERSITA' - Via A. Valerio, 2 - 34100 TRIESTE (ITALY)

4.1. The T(^{3}He,n)^{5}Li Reaction at ^{3}He Energies below 5.5 MeV.

U. ABBONDANNO, F. DEMANINS and C. TUNIZ

ISTITUTO DI FISICA DELL'UNIVERSITA' - TRIESTE
ISTITUTO NAZIONALE DI FISICA NUCLEARE - SEZIONE DI TRIESTE

G. NARDELLI

ISTITUTO DI FISICA DELL'UNIVERSITA' - PADOVA
ISTITUTO NAZIONALE DI FISICA NUCLEARE - SEZIONE DI PADOVA

A measurement of the angular distributions of neutrons emitted in the two proton transfer reaction T(^{3}He,n)^{5}Li has been performed.

The data were obtained by using the pulsed-beam time-of-flight technique at energies of the incident ^{3}He particles from 2.0 to 5.5 MeV, in steps of 0.5 MeV.

The experimental data have been compared with calculated curves obtained by describing the two-proton stripping (D.S.) in terms of the DWBA (1) and the knock-out process (K.O.) in terms of the Plane Wave Born Approximation (PWBA) (2).

The D.S. angular distributions have been calculated by means of the zero--range two-nucleon transfer option of the DWBA computer programme DWUCK (3). The adopted configurations for the two protons transferred to ^{5}Li were $1s_{1/2}$ and $1p_{3/2}$. The proton in the $1p_{3/2}$ shell was thought as having a little binding energy (50 keV). Only the $J_T = 1$ transferred angular momentum has been considered, as required by the selection rules for a $1/2^+ \rightarrow 3/2^-$ ($1/2^-$) transition from the ground state of T($J^\pi = 1/2^+$) to the ^{5}Li ground ($J^\pi = 3/2^-$) and first-excited ($J^\pi = 1/2^-$) state.

The K.O. angular distributions were calculated with the theory of Newns. In this case the values of $J_T = 1$ and $J_T = 3$ were taken into account, but the fit of the experimental data indicated that there is no $J_T = 3$ contribution to the angular distributions. The best results were obtained with an interaction radius of 5.5 fm.

The experimental data and the angular distributions calculated for the n_0 neutrons group and the two reaction mechanisms are reported in Figs. 1-4. The numerical values of the measured cross-sections are listed in Table I. In the figures, the dash-dotted line represents the D.S. contribution and the dashed line the K.O. contribution. The solid line represents the sum of the two contributions.

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(1) R.H. Bassel, R.M. Drisko and G.R. Satchler, ORNL 3240 (1962). N.K. Glendenning, Phys. Rev. 137, B102 (1965).

(2) H.C. Newns, Proc. Phys. Soc. 76, 489 (1960).

(3) P.D. Kunz, University of Colorado, unpublished.

The angular distributions of the n_1 neutron group from the first-excited level of $^5Li(J_Y^{\pi}=1/2^-)$ were interpreted with the D.S. mechanism only. In fact, the fit gave as result that the K.O. process does not contribute to the n_1 differential cross-section.

The configurations $1s_{1/2}$ and $1p_{3/2}$ were again assumed for the transferred protons. In this case also the change of parity between the ground state of $T(J_X^{\pi}=1/2^+)$ and the first-excited level of $^5Li(J^{\pi}=1/2^-)$ allows only odd values of the transferred angular momentum. The assumed value $J_T=1$ results from simple considerations on the spin of the interested levels.

The angular distributions calculated for the n_1 group (with the same optical model parameters for the ^3He-T and n-^5Li channels used in the case of the n_0 group) are compared with the experimental data in Fig. 5. The numerical values of the differential cross-sections are listed in Table II.

The analysis of the neutron spectra obtained in the present measurement has assigned to the first-excited level of ^5Li an excitation energy of $E_x \pm (10.21\pm0.28)$ MeV and a width $\Gamma = (2.28\pm0.58)$ MeV.

TABLE I - CROSS SECTIONS FOR THE $T(^3He, n_0)^5Li$ REACTION ($\mu b/sr$).

θ_{LAB}	$E_{^3He} \cong 2$ MeV, $\sigma(20^\circ) = 809\ \mu b$		$E_{^3He} = 2.5$ MeV, $\sigma(20^\circ) = 1113\ \mu b$		$E_{^3He} = 3$ MeV, $\sigma(20^\circ) = 1262\ \mu b$		$E_{^3He} = 3.5$ MeV, $\sigma(20^\circ) = 1300\ \mu b$		$E_{^3He} = 4$ MeV, $\sigma(20^\circ) = 1395\ \mu b$		$E_{^3He} = 4.5$ MeV, $\sigma(20^\circ) = 1375\ \mu b$		$E_{^3He} = 5.5$ MeV, Arbitrary units	
	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$
0°	0	713 ± 89	0	969 ± 113	0	1147 ± 147	0	920 ± 115	0	942 ± 138	0	960 ± 147	0	55233 ± 4519
10°											11.91	1116 ± 117		
20°	22.63	809 ± 79	22.91	1113 ± 122	23.16	1262 ± 145	23.40	1300 ± 133	23.56	1395 ± 189	23.77	1375 ± 172	24.07	90724 ± 6729
30°											35.52	1816 ± 214		
40°	44.95	712 ± 95	45.47	1345 ± 143	45.95	1499 ± 167	46.39	1495 ± 141	46.71	1764 ± 219	47.10	2253 ± 279	47.66	108235 ± 7970
50°											58.47	2162 ± 273		
60°	66.67	770 ± 98	67.38	1481 ± 170	68.03	1471 ± 169	68.63	1401 ± 135	69.05	1327 ± 131	69.59	2130 ± 278	70.35	100838 ± 7308
70°											80.41	1974 ± 239		
80°	87.59	556 ± 83	88.40	1241 ± 145	89.14	1160 ± 149	89.82	1141 ± 124	90.31	904 ± 130	90.92	1828 ± 245	91.78	92248 ± 6767
90°											101.09	1698 ± 248		
100°	107.58	692 ± 94	108.40	1370 ± 171	109.14	1179 ± 145	109.82	1108 ± 121	110.31	1005 ± 135	110.92	1451 ± 192	111.78	90524 ± 6587
110°											120.41	1593 ± 204		
120°	126.67	531 ± 82	127.38	1382 ± 183	128.03	1090 ± 164	128.63	1051 ± 121	129.05	906 ± 133	129.59	1369 ± 197	130.75	75184 ± 5512
130°											138.47	1494 ± 205		
135°	140.44	521 ± 84	141.02	974 ± 138	141.55	1034 ± 152			142.38	828 ± 128				
140°							146.39	1004 ± 119			147.10	{1186 ± 136 {1420 ± 180	147.66	70599 ± 5273
150°	153.85	437 ± 72	154.25	951 ± 127	154.62	1065 ± 146			155.21	692 ± 111	155.52	1133 ± 150		
160°							163.40	913 ± 116			163.77	954 ± 143	164.07	71891 ± 4592

TABLE I - CROSS SECTIONS FOR THE $T(^3He,n_o)^5Li$ REACTION ($\mu b/sr$).

θ_{LAB}	$E_{^3He}$ = 2 MeV $\sigma(20^o)$ = 809 μb		$E_{^3He}$ = 2.5 MeV $\sigma(20^o)$ = 1113 μb		$E_{^3He}$ = 3 MeV $\sigma(20^o)$ = 1262 μb		$E_{^3He}$ = 3.5 MeV $\sigma(20^o)$ = 1300 μb		$E_{^3He}$ = 4 MeV $\sigma(20^o)$ = 1395 μb		$E_{^3He}$ = 4.5 MeV $\sigma(20^o)$ = 1375 μb		$E_{^3He}$ = 5.5 MeV Arbitrary units	
	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$
0°	0	713 ± 89	0	969 ± 113	0	1147 ± 147	0	920 ± 115	0	942 ± 138	0	960 ± 147	0	55233 ± 4519
10°											11.91	1116 ± 117		
20°	22.63	809 ± 79	22.91	1113 ± 122	23.16	1262 ± 145	23.40	1300 ± 133	23.56	1395 ± 189	23.77	1375 ± 172	24.07	90724 ± 6729
30°											35.52	1816 ± 214		
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50°											58.47	2162 ± 273		
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70°											80.41	1974 ± 239		
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90°											101.09	1698 ± 248		
100°	107.58	692 ± 94	108.40	1370 ± 171	109.14	1179 ± 145	109.82	1108 ± 121	110.31	1005 ± 135	110.92	1451 ± 192	111.78	90524 ± 6587
110°											120.41	1593 ± 204		
120°	126.67	531 ± 82	127.38	1382 ± 183	128.03	1090 ± 164	128.63	1051 ± 121	129.05	906 ± 133	129.59	1369 ± 197	130.75	75184 ± 5512
130°											138.47	1494 ± 205		
135°	140.44	521 ± 84	141.02	974 ± 138	141.55	1034 ± 152			142.38	828 ± 128				
140°							146.39	1004 ± 119			147.10	$\begin{cases}1186 \pm 136\\1420 \pm 180\end{cases}$	147.66	70599 ± 5273
150°	153.85	437 ± 72	154.25	951 ± 127	154.62	1065 ± 146			155.21	692 ± 111	155.52	1133 ± 150		
160°							163.40	913 ± 116			163.77	954 ± 143	164.07	71891 ± 4592

TABLE II - CROSS SECTIONS FOR THE $T(^3He,n_i)^5Li$ REACTION (μb/sr).

θ_{LAB}	$E_{^3He}$ = 3.5 MeV		$E_{^3He}$ = 4 MeV		$E_{^3He}$ = 4.5 MeV		$E_{^3He}$ = 5.5 MeV	
	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$	$\theta_{c.m.}$	$\frac{d\sigma}{d\Omega}$ (arbitrary units)
0	0	231 ± 22	0	287 ± 41	0	359 ± 62	0	8268 ± 983
10					14.55	428 ± 32		
20	29.06	214 ± 22	29.02	254 ± 44	29.00	371 ± 62	28.97	9103 ± 935
30					43.21	482 ± 68		
40	57.22	187 ± 19	57.13	214 ± 36	57.09	409 ± 66	57.05	8309 ± 888
50					70.50	239 ± 41		
60	83.50	96 ± 10	83.38	99 ± 11	83.32	145 ± 35	83.26	6807 ± 799
70					95.44	55 ± 20		
80					106.76	107 ± 34	106.69	1793 ± 516

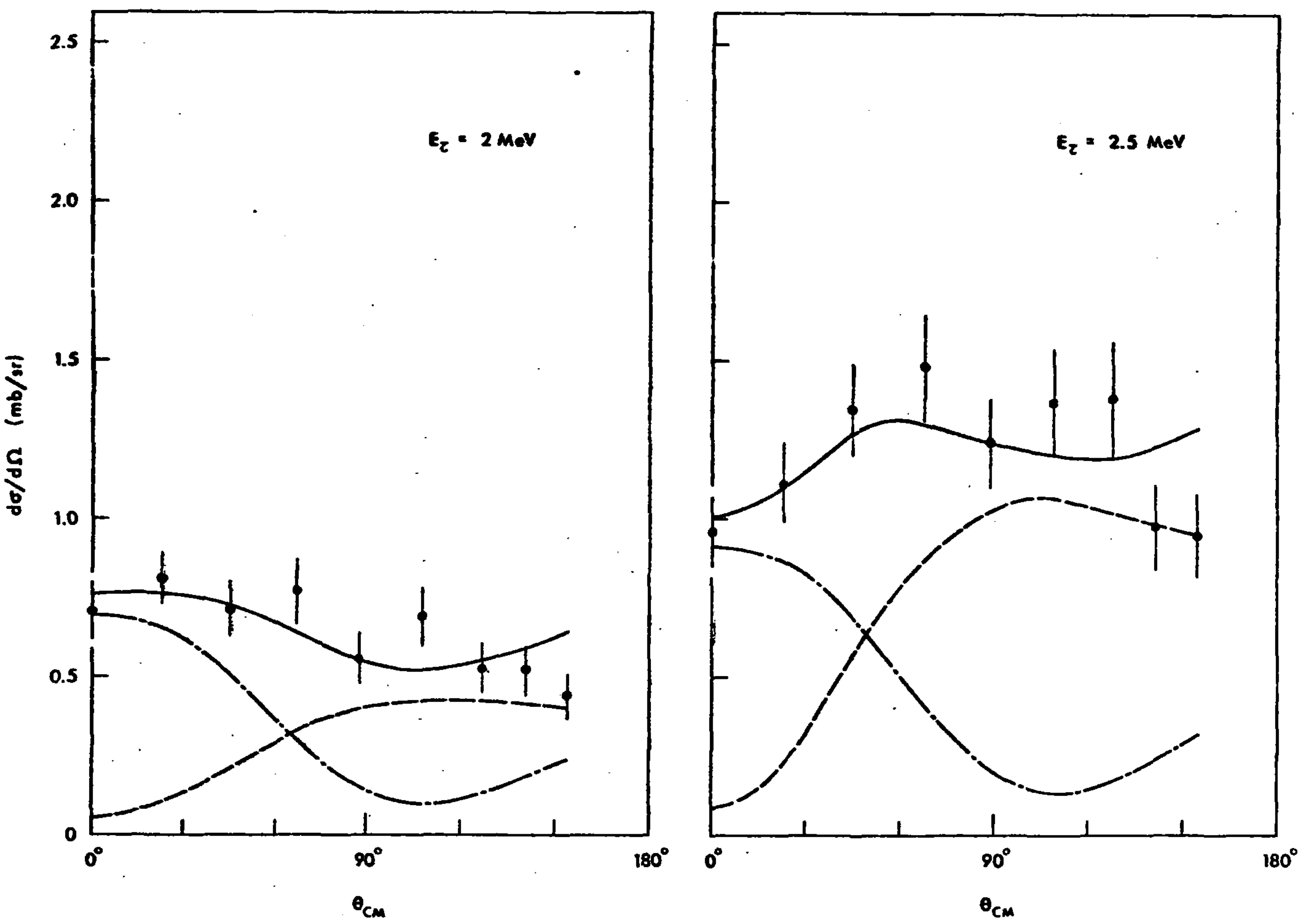


Fig. 1 - Experimental differential cross sections and calculated angular distributions at $E_{^3He}$ = 2.0 MeV and $E_{^3He}$ = 2.5 MeV for the n_0 neutron group. The dashed-dotted line represents the D.S. contribution and the dashed line the K.O. contribution. The solid line is the sum of the two contributions.

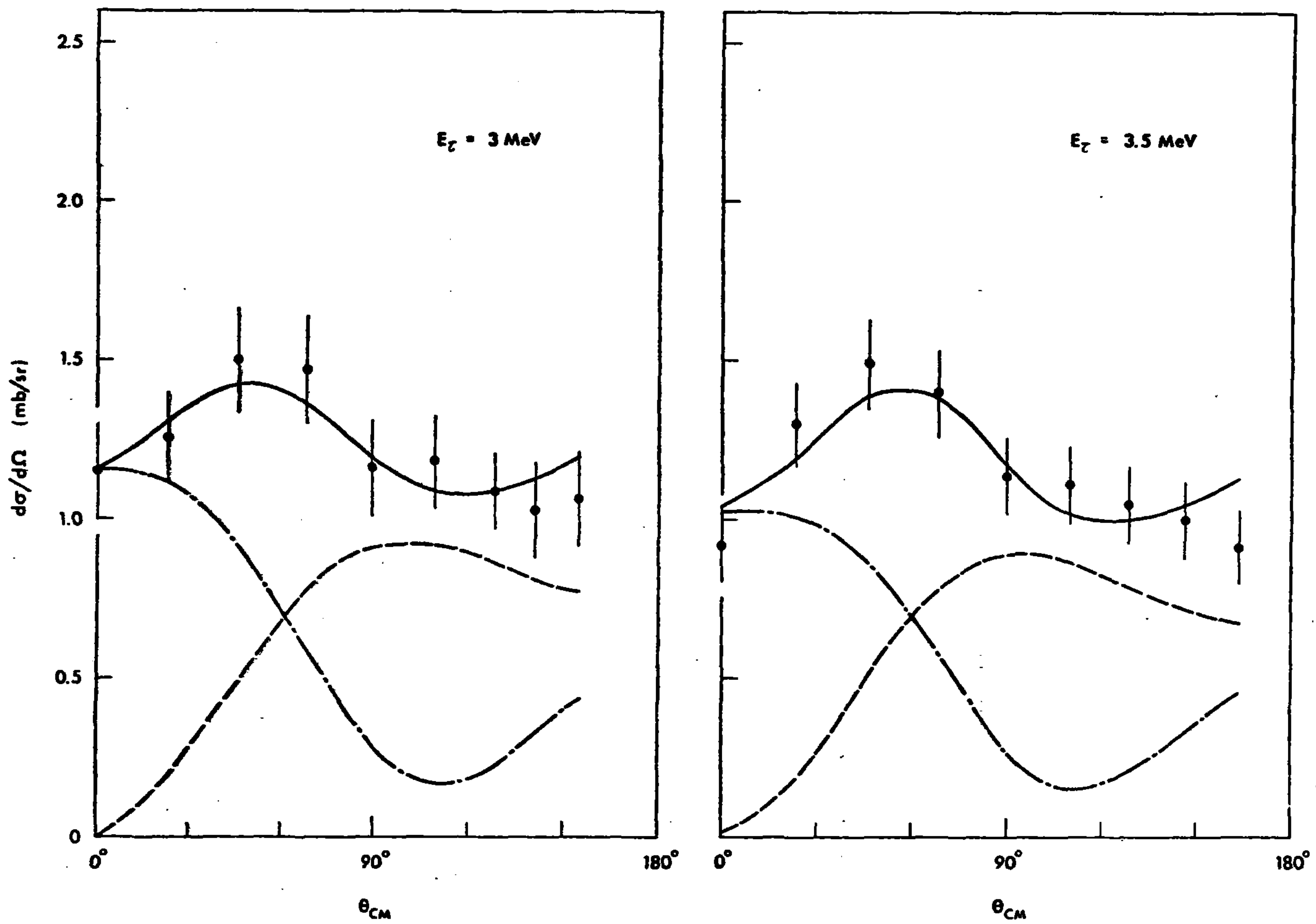


Fig. 2 - Experimental differential cross sections and calculated angular distributions at $E_{^3He}$ = 3.0 MeV and $E_{^3He}$ = 3.5 MeV for the n_0 neutron group. The dashed-dotted line represents the D.S. contribution and the dashed line the K.O. contribution. The solid line is the sum of the two contributions.

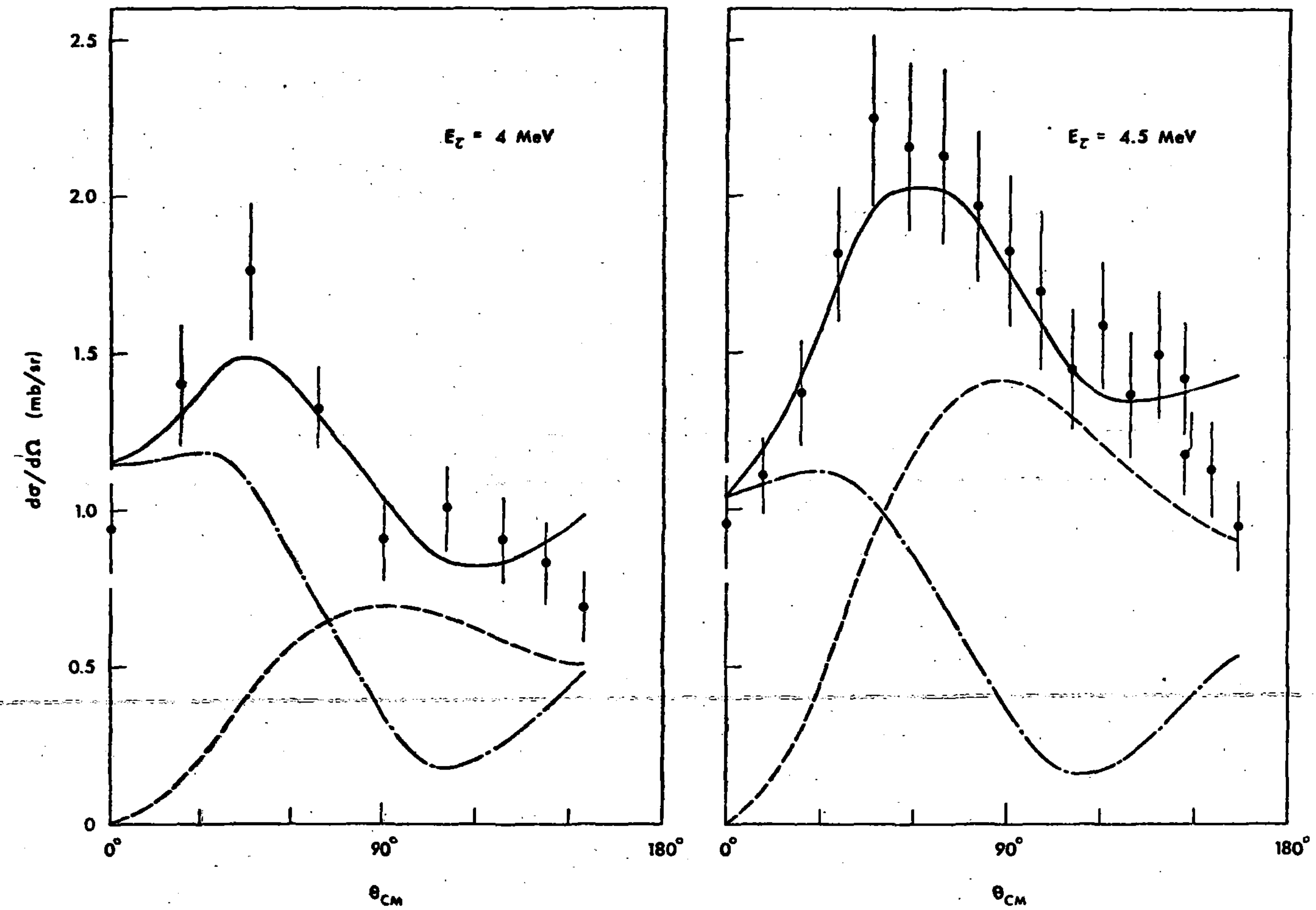


Fig. 3 - **Experimental differential cross sections and calculated angular distributions at $E_{^3He}$ = 4.0 MeV and $E_{^3He}$ = 4.5 MeV for the n_o neutron group. The dashed-dotted line represents the D.S. contribution and the dashed line the K.O. contribution. The solid line is the sum of the two contributions.**

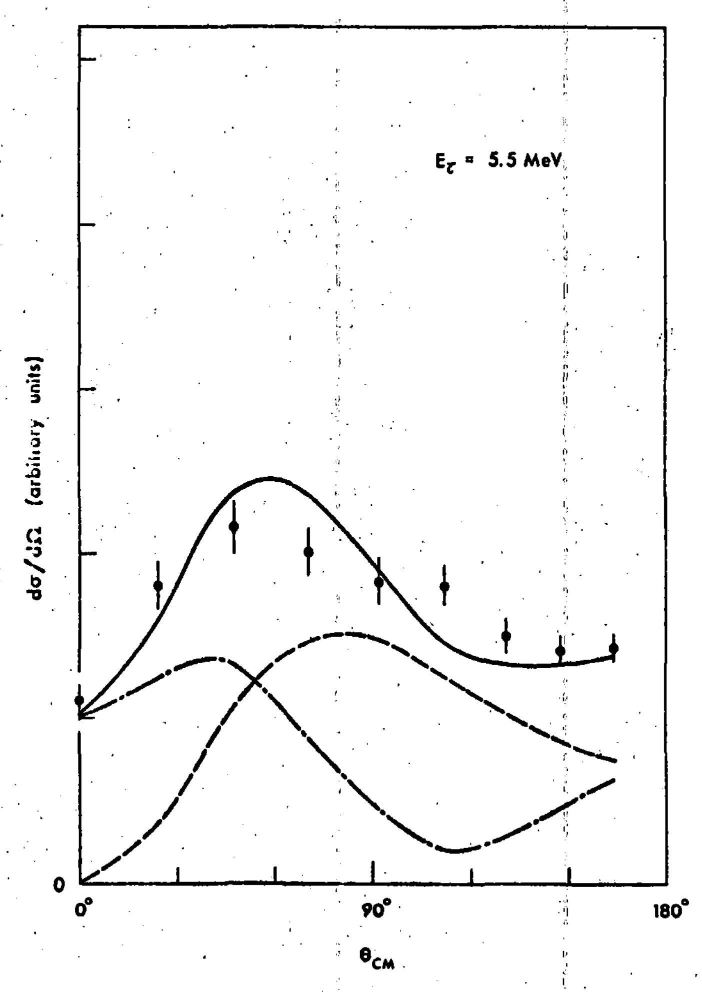


Fig. 4 - Experimental and calculated angular distributions at $E_{^3He}$ = 5.5 MeV for the n_0 neutron group. The dashed-dotted line represents the D.S. contribution and the dashed line the K.O. contribution. The solid line is the sum of the two contributions.

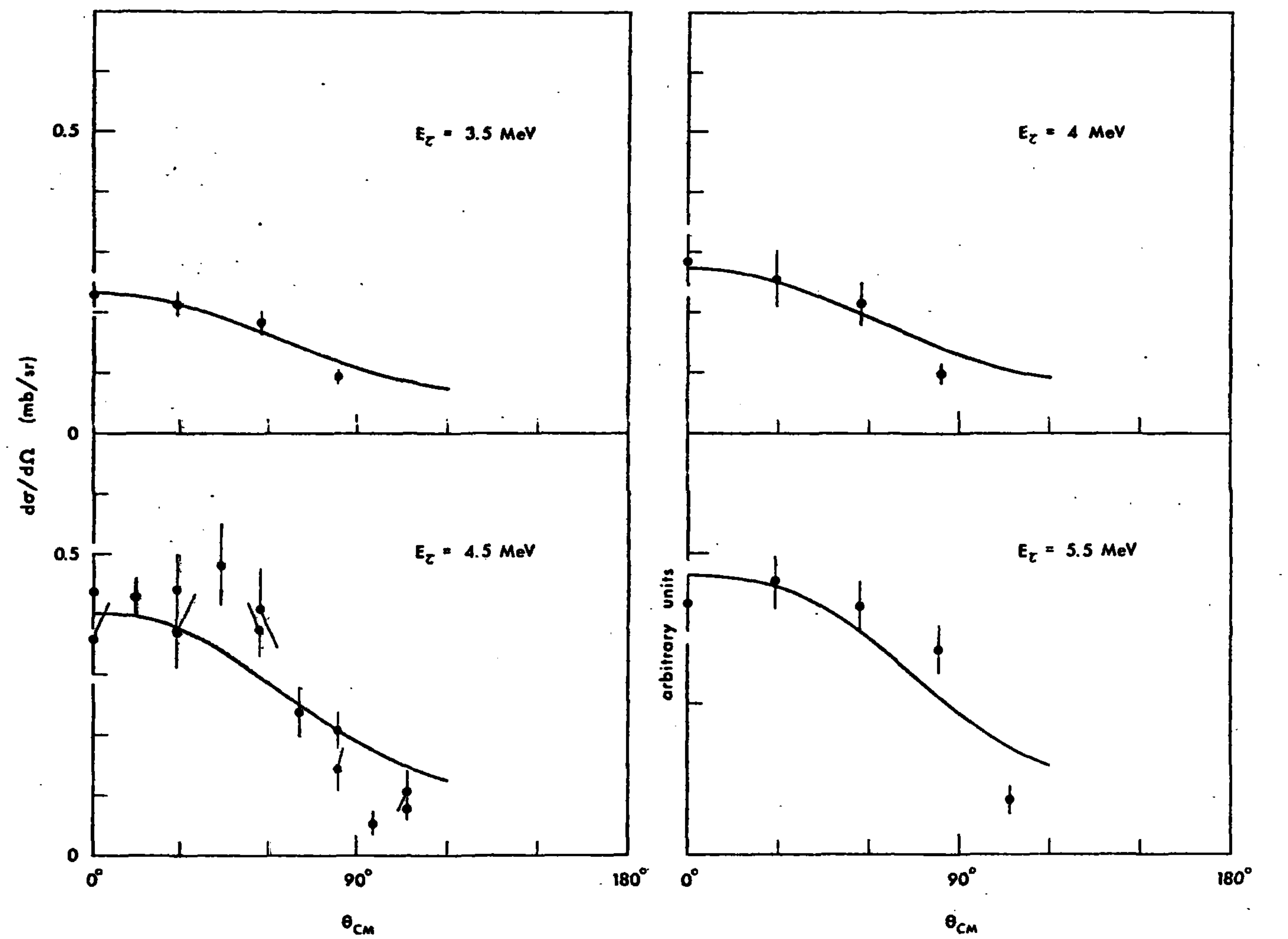
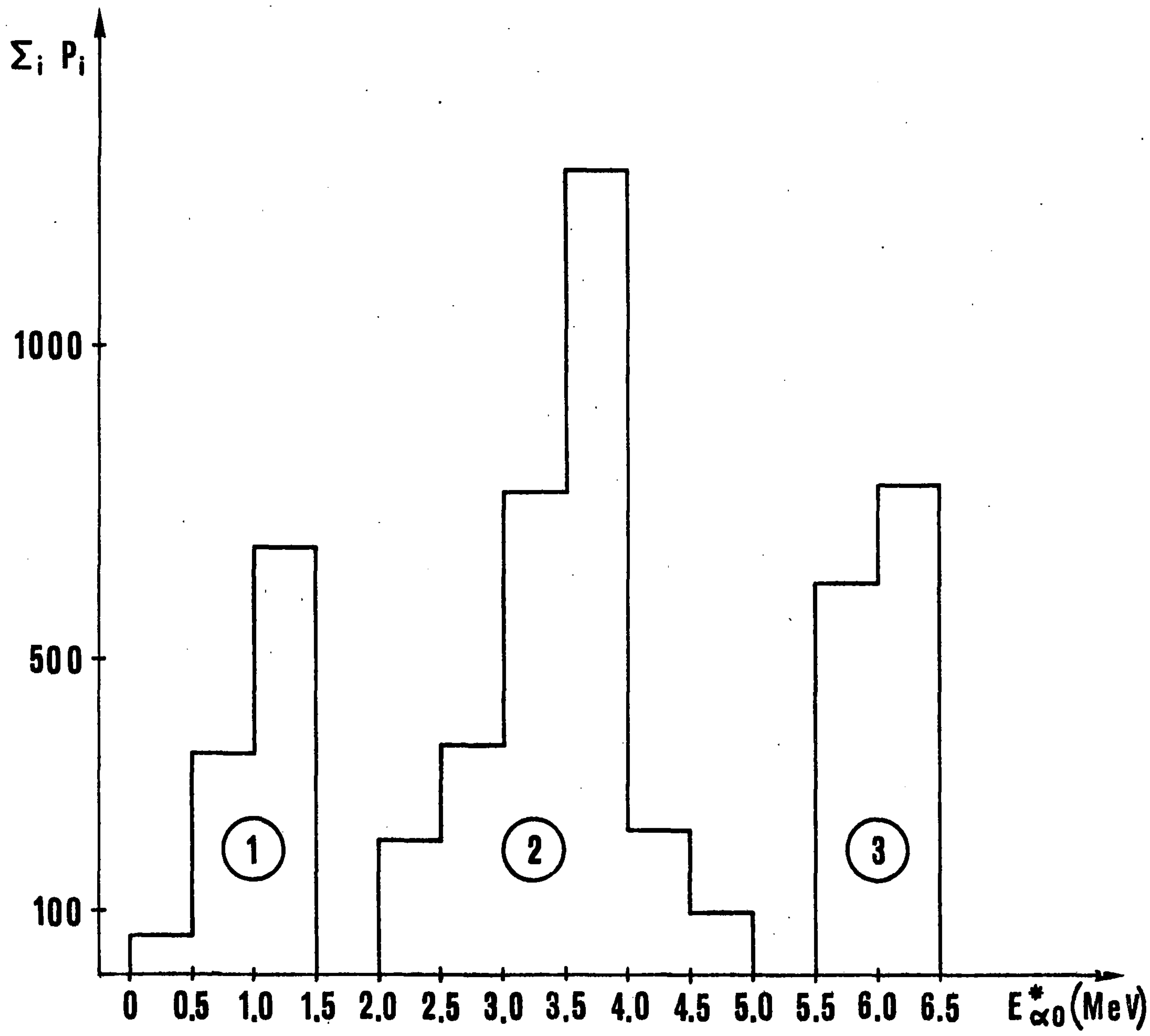


Fig. 5 - Measured differential cross sections at $E_{^3He}$ = 3,5 - 4,0 - 4,5 MeV, experimental angular distribution at $E_{^3He}$ = 5,5 MeV and angular distributions calculated for the D.S. reaction mechanism for the n_1 neutron group.



(1) → $\overline{D_0} = 22{,}3$ fm ; $\overline{E_{F0}} = 19{,}9$ MeV

(2) → $\overline{D_0} = 26{,}3$ fm ; $\overline{E_{F0}} = 43{,}4$ MeV

(3) → $\overline{D_0} = 26{,}7$ fm ; $\overline{E_{F0}} = 47{,}5$ MeV

Fig.1

5. CENTRO SICILIANO DI FISICA NUCLEARE E DI STRUTTURA DELLA MATERIA
ISTITUTO NAZIONALE DI FISICA NUCLEARE - SEZIONE DI CATANIA
ISTITUTI DI FISICA DELL'UNIVERSITA' DI CATANIA (ITALY)

5.1. Experimental research work on nuclear structure and reactions

5.1.1. Nuclear Fission

(V.Bellini, G.Bologna, V.Emma, A.S.Figuera, S.Lo Nigro, C.Milone and G.S.Pappalardo).

The photofission yields of Bi,Pb,Au and Pt induced by a coherent bremsstrahlung beam from 1000 MeV electrons striking a diamond single crystal have been measured.

The experiment has been performed at sixteen different energies of the main peak of the photon spectrum, in the energy range between 220 MeV and 500 MeV, by detecting the fission fragments with the glass sandwich technique. All the photon spectra have been measured simultaneously to the exposures of the fissionable samples by means of a magnetic pair spectrometer and a real time acquisition system with an on-line computer. An appropriate method was developed in order to deduce the behaviour of the photofission cross section from the experimental yields.

The estimated cross section curves clearly show a first resonance at a photon energy of about 320 MeV with a FWHM$\approx$125 MeV, whilst there is only a hint of a second broad resonance centred at K$\approx$750 MeV.

The very good agreement between the position of the first resonance put in evidence in the present experiment and the energy of the first baryon resonance in the pion photoproduction is attributed to a predominance of the photomesonic mechanism in the photofission process of the investigated elements (*) [1]).

5.1.2. (V.Emma, S.Lo Nigro and C.Milone)

The photofission cross section per equivalent quantum of 28 elements from Bi to Fe has been measured at 1000 MeV bremsstrahlung maximum energy. The fission fragments have been detected by means of the glass sandwich technique.
Informations are deduced on the dependence of the nuclear fissility on Z^2/A (**) [2]).

5.1.3. Three bodies reactions in the final state.
(N.Arena, Seb.Cavallaro, V.D'Amico, G.Fazio, S.Feminò, G.Giardina, S.Jannelli, F.Mezzanares, R.Potenza).

In order to investigate the reaction mechanism and the structure of the ^5Li intermediate nucleus in its first and second excitated states we studied the $^6Li+^3He \rightarrow \alpha + ^5Li$ reaction at 1.5,2.5 and 5.0 MeV bombarding energies.
Therefore we measured the bidimensional spectra of the α-α and α-p coincident particles.
The analysis of the experimental data is in progress.

5.1.4. ($^3He,\alpha$) reactions on ^{24}Mg, ^{25}Mg and ^{26}Mg.
(S.Notarrigo, F.Porto, A.Rubbino, S.Sambataro)

From the study of the reactions ($^3He,\alpha$) on the Mg-isotopes around 10 MeV, performed in the last years, we can say:

(*) Physics letters 52B (1974) 192

(**) V.Emma, S.Lo Nigro and C.Milone, Nucl.Phys. in press.

a) in the $^{26}Mg(^{3}He,\alpha)^{25}Mg$ reaction the statistical contribution to reaction can be neglected. The comparison between D.W.B.A. calculations and experimental angular distributions is poor, specially for the transition to $7/2^{+}$ state at 1.61 MeV of the ^{25}Mg (*);

b) in the $^{25}Mg(^{3}He,\alpha)^{24}Mg$ reaction, instead, the statistical contribution is quite relevant for the transitions leading to levels of the rotational band K=2.
In this reaction the D.W.B.A. calculations give much better agreement with the experimental data for all studied transitions[3,4].

c) In the $^{24}Mg(^{3}He,\alpha)^{23}Mg$ reaction, D.W.B.A. calculations reproduce quite well only the angular distributions relative to the transition leading to $5/2^{+}$ state at 0.44 MeV of the ^{23}Mg. For other transitions to the ground state and to the $7/2^{+}$ state at 2.08 MeV, we believe that the disagreement is to be attributed to a haevy-ion stripping contribution and inelastic effects respectively.

To account for inelastic effects in the studied reactions we have performed C.C.B.A. calculations using the Mars-code. First C.C.B.A. calculations including two steps only in the incident channel show better agreement with experimental data, but suggest to be necessary to consider two steps also in the autgoing channel.

(*) Nuovo Cimento 14A (1973) 403

5.1.5. (e,e'x) Experiments.
(J.P.Gênin, J.Julien, M.Rambaut, C.Samour, A.Palmeri, D.Vinciguerra)

Quasi free scattering of electrons from nuclear clusters has been investigated at the 600 MeV linear accelerator of the Saclay Center for Nuclear Reserach, France, within a collaboration between Catania and Saclay, for ^{6}Li, ^{9}Be and ^{24}Mg.
In particular the α-d relative impulse distribution in ^{6}Li has been fitted using several relative wave functions. The FWHM of the calculated distributions has been found to be almost model and parameter-indipendent, provided a wave function with the correct exponential esymptotic behaviour is used[5,6]).

5.1.6. (π,He) Reaction in ^{27}Al.
(Saclay - Tel Aviv - Catania Collaboration)

The study of π interaction in nuclei has been continued by further measurements of charged particle and gamma-ray spectra. The analysis of the data is under way.

5.1.7. High electron interaction on ^{4}He.
(D.Vinciguerra, S.Barbarino, E.Modica)

The study of the spectrum of ^{3}He ions produced by 2 GeV electron interaction on ^{4}He has given evidence for contribution of the barionic resonance Δ(1236) and N(1470) to the process[(*)].

5.1.8. Quasi Free Reactions at Low Energy.
(N.Arena, F.Riggi, C.Spitaleri, D.Vinciguerra)

Evidence for quasi free processes has been found for the

(*) High energy electron interaction on ^{4}He. - D.Vinciguerra, S.Barbarino and E.Modica, (to be published).

$^{9}Be(^{3}He,\alpha\alpha)\,^{4}He$ reactions (Q=19 MeV) at incident energy as low as 2.6 MeV. Further investigation of the process will include the study of the (distorted) momentum distribution and the measurement of similar High-Q reactions.

5.1.9. Study of 13.6 MeV ^{17}O level excited by $^{13}C(^{6}Li,d)^{17}O$ Reaction.
(A.Cunsolo, A.Foti, N.Saunier) (Saclay-Catania Collaboration)

The level at 13.6 MeV excitation energy in ^{17}O is very strongly populated by $^{13}C(^{6}Li,d)^{17}O$ reaction. In the weak coupling scheme two levels with spins $11/2^{-}$ and $13/2^{-}$ are predicted in ^{17}O at the same excitation energy range. These levels are obtained by coupling a neutron in $P\frac{1}{2}$ with the 6^{+} at 16.2 MeV excitation energy in ^{16}O.
In order to study the nature of this level we have performed experimental measurements[7]) of:

a) Excitation function from 20 MeV to 32 MeV incident ^{6}Li;

b) angular correlation, at 25 MeV incident ^{6}Li, of deutons emitted at 0° and alphas coming from ^{17}O decay to ^{13}C ground state.

The experimental tecnique has been previously described[8]).

5.1.10. Intermediate structure in the keV fission cross section of ^{235}U
(E.Migneco, P.Bonsignore, G.Lanzanò, J.A.Wartena, H.Weigmann)

The relative fission cross section of ^{235}U has been measured up to 200 keV with a nominal resolution of 1.0 ns/m, using a thin foil plastic scintillator detector. The data have been analysed in order to detect nonstatistical effects due to intermediate structure. Statistical tests which have been applied to this fission and similar total cross section data include calculations of the auto-correlation function and Wald-Wolfowitz testes on the cross-section and on the autocorrelograms. The comparison of the results indicates the presence of intermediate structure effects in fission cross-section which may be interpreted on the basis of the double-humped deformation potential[9]).

5.1.11. On Sub-Barrier Fission in ^{238}U
(J.A.Wartena, H.Weigmann, E.Migneco)

Sub-barrier fission in ^{238}U has first been observed by R.Block et al.(*), using ionization chambers for fission fragment detection. In the present measurements a liquid scintillator was used to detect prompt fission neutrons. Thereby, with a sample of 250 g of ^{238}U, neutron time-of-flight measurements could be performed at a 30 m flightpath with a nominal resolution of 1.3 nsec/m. The result of the present investigation is a full confirmation of the findings of Block et al.(*). This includes a confirmation, by high resolution data, of the fact that the resonances at 721.0 eV and 1210.7 eV contribute most strongly to the observed fission in the two sub-barrier structures at low neutron energies. Their fission widths are found to be (0.85±0.13) meV and (0.25±0.05) meV, respectively (assuming Γ_γ=23 meV). For most of the other resonances in these two structures only upper limits for the fission widths are obtained[10]).

(*) R.C.Block, R.W.Hockenbury, R.E.Slovacek, E.B.Bean, and D.S.Cramer, Phys.Rev.Lett. 31(1973)247.

REFERENCES

1) V.Bellini, G.Bologna, V.Emma, A.S.Figuera, S.Lo Nigro, C.Milone and G.Pappalardo Jr., Boll. SIF 106 (1975) 59.

2) V.Emma, S.Lo Nigro and C.Milone, Boll. SIF 106 (1975) 59.

3) S.Notarrigo, F.Porto, A.Rubbino, S.Sambataro Boll.SIF 106 (1975) 4.

4) S.Notarrigo, F.Porto, A.Rubbino, S.Sambataro and H.Nann Submited to Nuovo Cimento.

5) A.Palmeri, D.Vinciguerra, J.P.Génin, J.Julien, M.Rambaut, C.Samour.
Lettere N.C. 13 (1975) 693.

6) D.Vinciguerra, E.Modica, A.Palmeri, J.Julien, C.Samour, J.P.Génin.
Lettere N.C. 14 (1975) 333.

7) Rapport d'activité C.E.N. Saclay - Note C.E.A. (1975).

8) M.Avril, M.Lepareux, N.Saunier; A.Foti, G.Pappalardo, A.Strazzeri.
Lettres Journ.de Phys. 36 (1975) L-229.

9) E.Migneco, P.Bonsignore, G.Lanzanò, J.A.Wartena, H.Weigmann.
Nuclear Cross Sections and Technology - October 1975 pag.607.

10) J.W.Wartena, H.Weigmann, E.Migneco
Nuclear Cross Sections and Technology - October 1975 pag.597.

6. ISTITUTO DI FISICA DELL'UNIVERSITA' DI FIRENZE - Largo E. Fermi, 2 - (ARCETRI) - 50125 FIRENZE (ITALY)

6.1. The second excited state ^{53}Fe

P.A. MANDO', P. SONA, N. TACCETTI

The $^{50}Cr(\alpha,n)^{53}Fe$ reaction was used to populate low lying levels in ^{53}Fe at alpha particle energies ranging from 6 up to 11 MeV. The second excited state in ^{53}Fe has been definitely identified at 774.4 keV excitation energy by measuring the excitation function around the threshold energy and performing gamma-gamma coincidence measurements.

The new level (which is tentatively assigned spin parity $J^{\pi}=\frac{1}{2}-$) decays with a 33.3 keV transition to the first excited state and is fed with a 26% branching from the third excited level via a 649 keV gamma ray. The lifetime of the new level was measured by recording time spectra of the 33.3 keV line (detected in a planar germanium detector of the intrinsic type) with respect to the pick up from pulsed alpha particle beam at 7 MeV energy.

We obtained for the lifetime the value $\tau_m=(2.9\pm0.3)$ ns where the quoted error includes possible contributions from systematic errors.

The new data on ^{53}Fe lend support to the thesis that low lying levels can be assigned to two rotationals bands having $K^{\pi}=\frac{1}{2}^-$ and $K^{\pi}=7/2^-$.

6.2. Level scheme of ^{96}Tc

M. BINI, P.G. BIZZETI, A.M. BIZZETI-SONA, P. BLASI, A. OLMI, N. TACCETTI

New levels of ^{96}Tc have been observed with the ^{93}Nb $(\alpha,n\gamma)^{96}Tc$ reaction in the energy interval E_{α}= 10 to 14 MeV. Measurements have been done at the 7,5 MV Van de Graaff of the Laboratori Nazionali di Legnaro, with a $^{4}He^{++}$ beam of 20 - 100 nA.

An intrinsic Ge spectrometer with 0.6 keV resolution at 100 keV has been used to investigate the low energy part of the γ spectrum. In this way, it has been possible to confirm definitely the previously suggested [1]

(1) M. BINI, P.G. BIZZETI, A.M. BIZZETI-SONA, P. BLASI, A. OLMI, N. TACCETTI: Congresso S.I.F. - Lecce 1975 - Bollettino S.I.F. 106, 21 (1975).

level at 49,1 keV and to identify a few γ cascades feeding it. New levels have been found at 506.6,575.0, and 618.8 keV (which decay mainly to the 49 keV level), at 886.1 and 947.1 keV (which decay to the 575 keV level) and at 1062.7 keV decaying to the 49 and to the 575 keV levels). Measurements are in progress for spin and parity assignments.