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CROSS-SECTION FLUCTUATIONS IN THE $^{28}Si(\gamma,p)$ REACTION AT 17.6 MeV

by

P. G. BIZZETI, A.M. BIZZETI-SONA, M. BOCCIOLINI, G. DI CAPORIACCO
M. MANDO', (Istituto di Fisica dell'Università — Firenze).

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P. G. BIZZETI, *et al.*
16 Dicembre 1962
Il Nuovo Cimento
Serie X, Vol. 26, pag. 1412-1415

Cross-Section Fluctuations in the $^{28}Si(\gamma, p)$ Reaction at 17.6 MeV.

P. G. BIZZETI, A. M. BIZZETI-SONA, M. BOCCIOLINI,
G. DI CAPORIACCO and M. MANDÒ

Istituto di Fisica dell'Università - Firenze
Istituto Nazionale di Fisica Nucleare - Sottosezione di Firenze

(ricevuto l'1 Ottobre 1962)

The favourable prospects of the ^7Li+p γ-radiation for the study of nuclear cross-section fluctuations has been discussed in another letter (1).

We report here the results of preliminary experiments on the $^{28}Si(\gamma, p)$ and $^{28}Si(\gamma, \alpha)$ reactions by using the above mentioned radiation, with a γ energy around 17.64 MeV. A proton beam of about 470 keV was made to impinge on a thick natural Li target. The beam was supplied by a van de Graaff type PN400 of the High-Voltage Eng. Corp.; since the accelerator was designed for only 400 kV, we had to introduce special precautions and care to insure a regular operation at 470 kV and in particular we were obliged to limit beam intensity to about 30 to 40 μA; this in turn forced on a geometry too packed, which otherwise could have been avoided.

The above photodisintegrations were observed by means of a silicon-junction detector (Hughes SD1/27, surface 1 cm^2) exposed to the γ-ray beam at various angles, with respect to the proton beam; the silicon detector thus served both as target for the γ's and as detector for the charged particle products. The detector surface was in a plane through the lithium target and its center was 2.5 cm apart from it.

The detector was operated at a voltage of 200 V, which gives an effective thickness > 350 μm and therefore an effective volume > 0.035 cm^3.

The pulse spectrum from the detector was analysed by suitable electronics: typical spectra are shown in Fig. 1: proton peaks are clearly apparent corresponding to proton transitions to the ^{27}Al ground state, 1-st excited and 2-nd excited states; α transitions to the ^{24}Mg ground state and 1-st excited state also emerge clearly from the strong electron background, although their quantitative measurement is subject to higher uncertainty.

Measurements were taken at angles from $\theta = 0°$ to 120° in equal steps for $\cos\theta$; the corresponding Doppler shifts in energy (evaluated at the resonance proton energy of 441 keV, laboratory system) are $+67.7$, 50.8, 33.9, 16.9, 0, -16.9, and -33.9 keV with respect to the γ-ray energy of 17.642 MeV at $\theta = 90°$.

(1) M. MANDÒ: *Nuovo Cimento*, **26**, 1416 (1962).

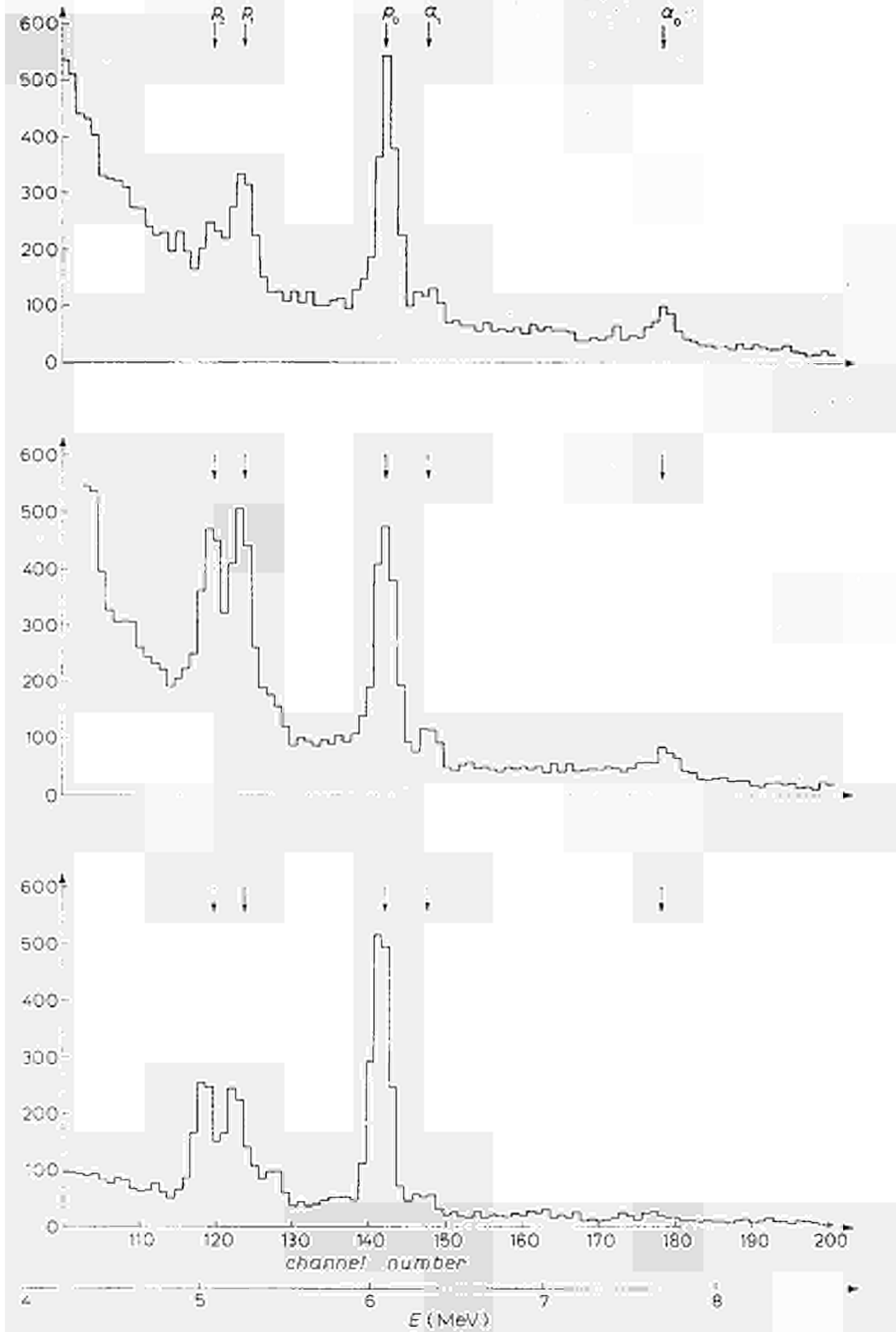

Fig. 1. – Typical ^{93}Nb(γ, p) and (γ, α) energy spectra at various excitation energies near 17.64 MeV. The energy shifts ΔE of incident γ-rays are, from the top, +67.8, +16.9 and −33.0 keV, respectively. Note shifted energy-zero.

The results were elaborated by taking the relative intensities of the p_2, p_1 and α_0 transitions with respect to the p_0 transition; this procedure removes many uncertainties which otherwise would have been very difficult to eliminate in this preliminary set of measurements.

These intensity ratios are tabulated in Table I, due allowance being made for the background; since in the present experimental conditions the p_2 and p_1 peaks partially overlap in the pulse spectrum, the ratio $(p_1+p_2):p_0$, which is better defined, is also shown in Table I.

TABLE I.

Values of relative intensity of the various peaks with respect to p_0 (*)

θ	$\cos\theta$	Energy shift (keV)	(p_1+p_2/p_0)	p_1/p_0	p_2/p_0	α_0/p_0
0°	+ 1.00	+ 67.8	0.70 ± 0.06	0.53 ± 0.05	0.17 ± 0.03	0.17 ± 0.02
41° 30′	+ 0.75	+ 50.8	1.04 ± 0.06	0.77 ± 0.05	0.27 ± 0.03	0.16 ± 0.02
60°	+ 0.50	+ 33.9	1.44 ± 0.08	0.90 ± 0.05	0.54 ± 0.03	0.15 ± 0.02
75° 30′	+ 0.25	+ 16.9	1.73 ± 0.10	0.87 ± 0.06	0.86 ± 0.06	0.17 ± 0.02
90°	0	0	1.41 ± 0.08	0.71 ± 0.05	0.70 ± 0.05	0.15 ± 0.02
104° 30′	− 0.25	− 16.9	0.84 ± 0.04	0.38 ± 0.03	0.46 ± 0.03	0.06 ± 0.01
120°	− 0.50	− 33.9	0.84 ± 0.05	0.43 ± 0.03	0.41 ± 0.03	< 0.03

(*) Errors shown are only statistical errors; maximum uncertainties of other origin (background evaluation, separation of neighbouring peaks, wall effects, etc.) are estimated to range from 18 to 7% for lower and higher values respectively. In addition a possible uncertainty in the geometrical conditions (estimated to be less than 7°) may introduce a systematic error in the value of the energy shift which ranges from 1.5 keV at 0° to 8.5 keV at 90°. The energy-spread for every single point, however, is determined essentially by the width of the resonance as ±6 keV. The ratios shown were evaluated through an objective criterion suitably choosen for the best separation of the peaks; as a result, the values may be expected to differ somewhat from the cross-section ratios for transitions to the corresponding final levels. They are, however, proportional to them through a factor which is about 1 and does not depend on energy.

In spite of the preliminary character of this series of measurements, we believe that the following interesting features are already clearly shown by the results in Table I and Fig. 2:

1) in the explored range of 100 keV strong cross-section fluctuations occur;

2) fluctuations for different final levels are uncorrelated;

3) the fluctuations seem to be very big, apparently bigger than those experimentally observed by other authors [2-4], with atoms of about the same A (and at higher excitation energy);

4) the energy width of the fluctuations, on the contrary, seems to be of the same order (though perhaps smaller) compared to what has been already reported by other authors [2-4], and therefore greater than the most reasonable theoretical estimates (see, *e.g.* *l. c.* [2]).

[2] L. COLLI, U. FACCHINI, I. IORI, M. G. MARCAZZAN, M. MILAZZO, E. SAETTA-MENICHELLA and F. TONOLINI: *Energia Nucleare*, **9**, 439 (1962).

[3] U. FACCHINI: *Padua Conference* (1962).

[4] L. COLLI: *Padua Conference* (1962).

Though the implications of features 3) and 4) may be strongly limited by the restricted range of energy which has been explored and the small number of independent experimental data, one cannot avoid to point out that all the above features would fit quite nicely the predictions of Ericson's theory of fluctuations (5) for the case of $\Delta E < \bar{\Gamma}$ and overlapping levels; it would be premature, however, to consider the above results as giving a definite proof of this interpretation.

In any case the above points and especially points 3) and 4), if substantiated by further experiments, appear to be most interesting in view of the fact that they were obtained with the best energy definition reported to date (that is about 12 keV, corresponding to the full width of the resonance for the $^7Li + p$ reaction).

Further experiments are in progress to improve experimental conditions (intensity, monitoring, effective volume of the detector, and reduced background) in order to be able to draw more definite and quantitative conclusions and to extend the results.

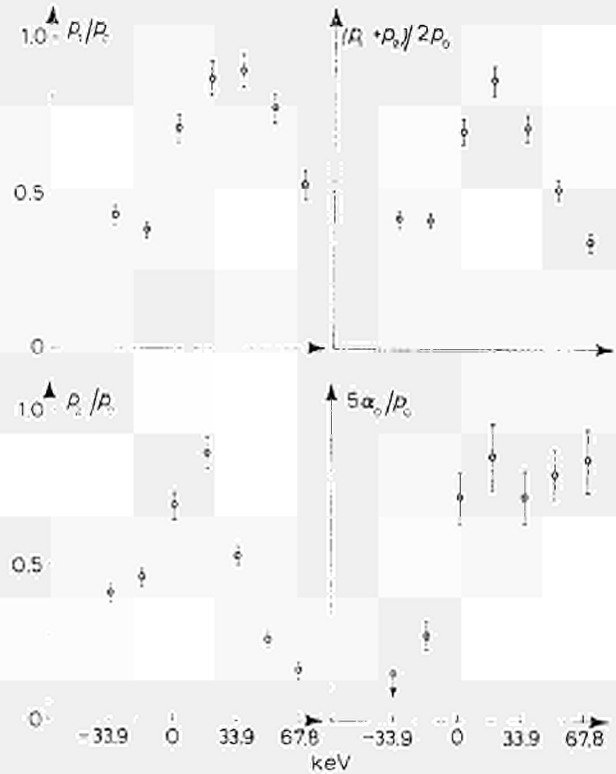

Fig. 2. – Intensity ratio of the various peaks with respect to p_0 vs. energy shift of incident γ radiation.

* * *

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(5) T. ERICSON: *Adv. in Phys.*, **9**, 415 (1960); *Phys. Rev. Lett.*, **5**, 430 (1960).

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