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PHOTOPRODUCTION OF BE FROM CARBON, BORON, BERILLIUM, AND LITHIUM--ETC(U)
APR 77 V I NOGA, Y M RANYUK, P V SOROKIN

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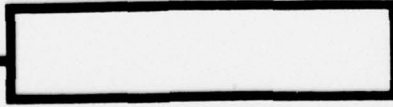
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V. I. Noga, Yu. M. Ranyuk, et al.



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"PHOTOPRODUCTION OF Be^7 FROM CARBON,
BORON, BERILLIUM, AND LITHIUM"

V. I. No⁸ya, Yu. M. Ranyuk, P. V.
et al.

The study of the photoproduction of Be^7 from light nuclei is interesting from the point of view of obtaining information on the mechanism of interaction of high-energy gamma quanta with atomic nuclei. Be^7 is a convenient residual nucleus for the study of nuclear reactions through activation methods. A great number of works now exist in which there is studied the production of the residual nucleus Be^7 under exposure to high-energy protons.

The photoyield of Be^7 was studied in works /1-8/ for $E_{\gamma\text{max}} = 60$ Mev. An exception is the measurements of the yield of Be^7 from carbon /1,2/ that were carried out for a maximal bremsstrahlung of up to 1,000 Mev.

In the present work there are measured the yields of Be^7 from natural isotopic mixtures of the nuclei of carbon, boron, berillium, and lithium in the range of energy $E_{\gamma\text{max}}$ from 80 to 1,180 Mev.

Procedure

The decay of Be^7 was identified from the half-life T and energy ϵ of photons formed in the decay of Be^7 as diagrammed in Figure 1 /9/.

A characteristic feature of the reactions studied is a relatively low induced activity per unit of radiation passing through the target. This is connected with the small magnitude of the cross section, the long half-life of the nucleus Be^7 , and the small probability of the transition into a state with energy of 479Mev of Li^7 . To shorten the time of radiation the targets were gathered in piles, which were irradiated by electron beams of linear accelerators at 360Mev. and 2 Bev. at the Kharkov Physico-Technical Institute of the Academy of Sciences of the Ukrainian SSR /10/. The characteristics of the targets are given in the table.

Element	Physical State	Mechanical Form	Thickness of Target, g./cm.
Li	Metal	Pressed in container	0.534
Be	Metal	Plate	0.545
B	Powder	Pressed in container	0.685
C	Graphite	Plate	0.43

To avoid oxidation the metal lithium was pressed into aluminum hermetic containers with a diameter of 30 mm. and a thickness of walls of ~0.1 mm. Measurements showed that the activity induced in the container could be ignored. The boron targets were prepared by pressing the powder-like boron into the same containers. All the targets had a natural isotopic make-up.

The yield of Be^7 was measured with respect to the reaction $\text{Al}^{27} \rightarrow \text{Ne}^{24}$. Unfortunately, the yields of this reaction which are measured in various works [11-15] differ substantially. As a result of supplementary measurements we carried out of the yield of the reaction $\text{C}^{12} \rightarrow \text{C}^{11}$ [15] for $E_{\gamma\text{max}} = 150$ Mev., preference was given to the results of Meyer et al. [13] and Messaferri [12] (see Figure 2).

The procedure of irradiating the targets was as follows. An electron beam was directed at a tantalum radiator with a thickness of 0.1 radiation units. Directly behind the radiator there was placed a pile of targets. In such an arrangement of the experiment, unlike work with a beam of bremsstrahlung, the time of exposure in the irradiation of the targets is practically not affected by the energy of the electrons. A short-coming of the method is the necessity of corrective separation of the contributions of electro- and photoactivation.

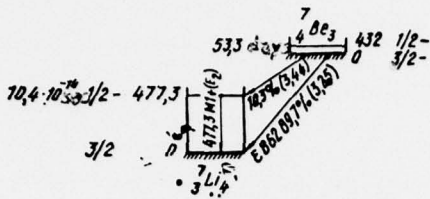


Figure 1. The decay of Be^7 /10/.

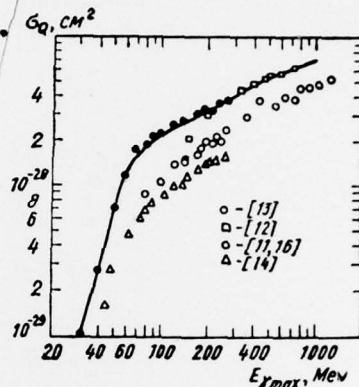


Figure 2. The dependence of the yield of the reaction $Al^{27} \rightarrow Ne^{24}$ on the maximal bremsstrahlung energy.

When electrons pass through matter there arises bremsstrahlung, whose intensity is proportional to the length of the braking distance passed through by the electrons. It is not difficult to see that the yield of the nuclear reaction for one electron and nucleus-target has the form

$$Y(E_e, t) = \sigma_e(E_0) + \sigma_Q(E_0)t = \sigma_Q(t + t_{equiv}) \quad (1)$$

Here σ_e is the cross-section of electroactivation, σ_Q is the cross-section of photoactivation for one equivalent photon, t is the braking distance in radiation units, $t_{equiv} = \frac{\tau_e}{\sigma_Q}$ is the equivalent radiation thickness, which is taken as equal to 0.025 in accordance with the findings of work /10/.

Relationship (1) is valid for values of t that are small by comparison with the radiation unit.

The time of exposure for a stream of electrons onto the converter of ~ 1 microampere was 2 hours for Li, B, and C and 20 minutes for Be. The berillium targets were irradiated

separately from the others to avoid the activation of the targets by photoneutrons. The decay of the residual nucleus Be^7 was registered by a scintillation spectrometer with an NaJ(Tl) crystal with dimensions of 60×60 cm. /9/ connected with an AI-128-1 amplitude analyzer. The NaJ crystal with a photomultiplier was located in a protective lead casing with walls 5 cm. thick.

Measurements were performed two months after irradiation. With the aid of a Ge(Li) -detector there were made control tests suggesting that the contribution of annihilation γ -quanta was practically absent.

Calculation of the reaction cross-sections was performed by the method of minimal structure /16/. The computations were done on an M-220 electronic computer.

Results and Discussion

$\text{C}^{12} \rightarrow \text{Be}^7$. The reaction of photoproduction of Be^7 from carbon was proposed by Nepoli /2/ as a monitor reaction for high energy photons. The absolute cross-section obtained in this study equals (0.12 ± 0.02) millibarn and is constant in the 400-900 Mev. photon energy range.

From Figure 3 it is apparent that the cross-sections obtained by us within the limits of error agree with the results of measurements by other authors /2-5,7,8,17/. The absolute cross-section $\sigma_K = (0.13 \pm 0.03)$ millibarn for $E_{\text{thresh}} = 26.3$ Mev. (the heat of the reaction $\text{C}^{12}(\gamma, \alpha n)\text{Be}^7$). The yield curve corresponding to this cross-section and depicted in Figure 3 by the broken line agrees within the limits of error with the experimental points, except for energies $E_\gamma \geq 1,000$ Mev, where there is observed a tendency of the cross-section to increase.

$\text{B} \rightarrow \text{Be}^7$. The yield of Be^7 from borium for one nucleus of

the target is shown in Figure 3. The absolute cross-section $\sigma_K = (0.06 \pm 0.02)$ millibarn for $E_{\text{thresh}} = 20$ Mev.

PW = present work

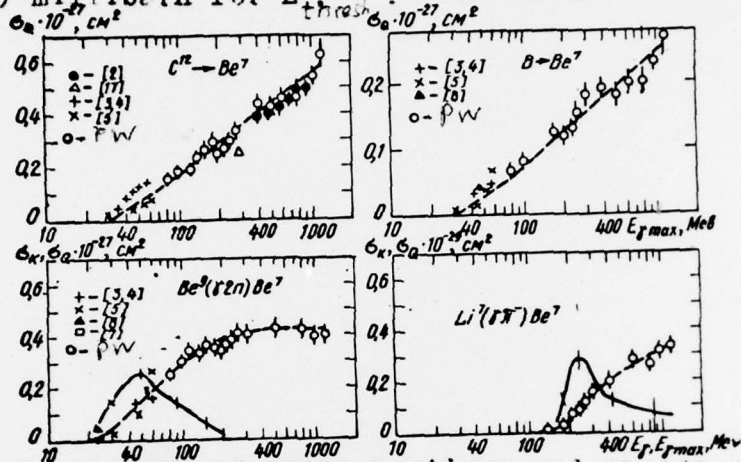


Figure 3. Energy dependency of cross-sections and yields of reactions: \circ - experimental relationship of yield to $E_{\gamma\text{max}}$; unbroken curve - σ_K - excitation function, calculated by the method of least squares from experimental data; broken curve - σ_Q - yield corresponding to the excitation function.

$\text{Be}^9 \rightarrow \text{Be}^7$. The heat of reaction $Q = -20.6$ Mev.

The cross-section of photogeneration of two neutrons on berillium in the region of "giant resonance" was not measured because it is difficult to recreate the excitation function for this reaction. In Figure 3 the broken curve shows the machine approximation of the yield $\sigma_Q(E_{\gamma\text{max}})$, the solid curve is the calculated value of $\sigma_K(E_\gamma)$.

From the diagram it is apparent that the form of the cross-section curve is close to the curve for the relation of the full cross-section of deuteron photodisintegration to the energy of the photons, which fact, in our opinion, argues for a quasi-deuteron mechanism for the reaction $\text{Be}^9(\gamma 2n)\text{Be}^7$.

The fact that the cross-sections of photoproduction of Be^7 from carbon and boron are independent of the energy of the photons, suggests that in those reactions for $E_\gamma > 150$ Mev. an

essential role is played by the processes of photoproduction of π -mesons within the nucleus.

$\text{Li}^7 \rightarrow \text{Be}^7$. The relation of the reaction yield to the maximal energy of the braking spectrum is shown in Figure 4. It is apparent that there is taking place the yield of Be^7 below the threshold of photoproduction of π -mesons, which is due to the photoproduction of Be^7 in impurities and the reaction $\text{Li}^7(\text{pn})\text{Be}^7$ on secondary protons. We considered the energy dependence of the yields of the reactions that are responsible for the production of Be^7 in the pre-threshold region to be the same as for the reaction $\text{C}^{12} \rightarrow \text{Be}^7$. The normalized for pre-threshold activity yield of this reaction is shown in the figure by a broken line. The yield after elimination of the background and the excitation function of the reaction are shown in Figure 3. The excitation function was approximated by a fifth order polynomial.

The reaction $\text{Li}^7(\gamma\pi^-)\text{Be}^7$ is very convenient for theoretical interpretation since in the Be^7 nucleus there are only two bound levels. No one, however, has yet calculated the cross-section of this reaction. It can be estimated with respect to the cross-section of a known reaction, for example, $\text{B}^{11}(\gamma\pi^-)\text{C}^{11}$, as was done by Meyer and others, from the relationship

$$\frac{\sigma[\text{Li}^7(\gamma\pi^-)\text{Be}^7]}{\sigma[\text{B}^{11}(\gamma\pi^-)\text{C}^{11}]} = \frac{N_n(\text{Li}^7) N_k(\text{Be}^7)}{N_n(\text{B}^{11}) N_k(\text{C}^{11})} \quad (2)$$

where N_n and N_k are the numbers of initial and final states. As was shown in work /18/, $N_n(\text{B}^{11})=4$; $N_k(\text{C}^{11})=15$.

In the initial state of the Li^7 nucleus there take part in photoproduction two neutrons with the configuration $1P_{\frac{3}{2}}$. The Be^7 nucleus has two levels, including the basic state of nucleons stable for emission with the configuration $1P_{\frac{3}{2}}$, which gives four final states for Be^7 . Substituting these values in (2), we obtain

$$\frac{\sigma[\text{Li}^7(\gamma\pi^-)\text{Be}^7]}{\sigma[\text{B}^{11}(\gamma\pi^-)\text{C}^{11}]} = 0,20. \quad (3)$$

There was experimentally obtained the value 0.3 ± 0.1 .

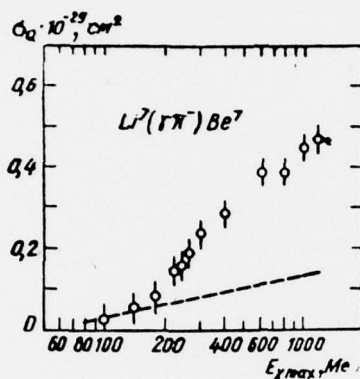


Figure 4. The relationship of the yield of Be^7 from Li^7 to $E_{\gamma\text{max}}$: the broken line is the background activity.

Bibliography

1. V. di Napoli et al., Nuovo Cim., **55B**, 95, 1968.
2. V. di Napoli, Nucl. Instr. and Method., **69**, 155, 1969.
3. H. Artus, G. Fricke, D. E. Von Stein, Zs. Phys., **178**, 109, 1964.
4. H. Artus, Zs. Phys., **189**, 355, 1966.
5. Y. Oka, T. Kato, A. Yamadera, Bull. chem. soc. Japan, **42**, 981, 1969.
6. K. H. Lokan, Proc. Phys. Soc. Lond., **A70**, 836, 1957.
7. M. S. Foster, A. E. Voight, J. Inorg. Nucl. Chem., **24**, 343, 1962.
8. O. L. Garson, G. G. Rocco, J. Inorg. Nucl. Chem., **29**, 1, 1967.
9. B. I. Noga, Ю. Н. Раныук, П. В. Сорокин, УФЖ, **13**, № 12, 1968.
10. Б. С. Дзелепов, Л. К. Пекер, Схемы распада радиоактивных ядер. М. Изд-во АН СССР, стор. 196.
11. Ю. П. Антупьев, И. И. Мирошниченко, В. И. Ноба, П. В. Сорокин, ЯФ, **6**, 431, 1967.
12. A. Massaike, J. Phys. Soc. Japan, **19**, No 4, 427, 1969.
13. R. A. Meyer, W. B. Walters, S. P. Hummel, Nucl. Phys., **A122**, 606, 1968.
14. А. Н. Горбунов, Ф. П. Денисов, В. А. Колотухин, ЖЭТФ, **38**, 1684, 1960.
15. W. C. Barber, W. P. George, P. P. Reagan, Phys. Rev., **98**, 73, 1955.
16. B. C. Cook, Nucl. Instr. and Method., **24**, 256, 1963.
17. G. Moscati, B. M. K. Nefkens, J. Todoroff, Bull. Am. Phys. Soc., **9**, 407, 1964.
18. R. A. Meyer, W. B. Walters, S. P. Hummel, Phys. Rev., **138**, 6B, 1421, 1963.
19. P. Dyal, S. P. Hummel, Phys. Rev., **127**, 2217, 1967.

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9. V.I. Noga, Yu.N. Ranyuk, P.V. Sorokin, UFZh, **13**, no.12, 1968.
10. B.S. Dzheleпов, L.K. Pekar, Schemes of decay of radioactive nuclei, Moscow, ANUSSR, p.196.
11. Yu.P. Antuf'ev, I.I. Miroshnichenko, V.I. Noga, P.V. Sorokin, YaF, **6**, 431, 1967.
14. A.N. Gorbunov, F.P. Denisov, V.A. Kolotukhin, ZhETF, **38**,

1084, 1960.

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PHOTOPRODUCTION OF Be^7
FROM CARBON, BORON, BERILLIUM AND LITHIUM

V. I. Noga, Yu. N. Ranyuk, P. V. Sorokin, V. A. Tkachenko

Summary

The nuclide Be^7 was produced by irradiating carbon, boron, berillium and lithium with bremsstrahlung from the Kharkov electron linear accelerator. Yield curves are measured and cross-sections are calculated for photons up to 1180 MeV.

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