tions). For the total energy free in the reaction (accounting the loss of 18.2 Mev for the binding energy) we have, therefore, the value 140.6 Mev, which corresponds very well to the π^--meson rest energy (139.6 Mev). Consequently, in our case, Li^8 fragments are produced either in ground state or with an excitation energy less than 2 Mev. This follows also from the fact that, for excitation energies larger than ~ 2 Mev, Li^8 should disintegrate emitting a neutron. The yield of reaction (3), estimated under the assumption that the probability of π^- meson capture by any emulsion nucleus is proportional to the number of nuclei of a given type,[7] amounts to $\sim 0.2\%$ of the total number of captures by beryllium.

The character of the observed disintegrations is clearly in disagreement with the assumption that the rest energy of the π^- meson is distributed, in the primary act, among a group consisting of a small number of nucleons. If such a group consisted even of 4 nucleons, the excitation energy of Li^8 should have amounted to not less than ~ 30 Mev. Consequently, the fast neutron obtains its energy as the result of an interaction in which take part all nucleons of the residual Li^8 nucleus.

The existence of disintegrations corresponding to reaction (3) indicates that collective interactions of nucleons in the nucleus can play an important role in the process of slow π^--meson absorption. A study of a wider class of stars confirms this conclusion.

The author thanks the supervisor of the work, Prof. V. I. Veksler, for constant interest and valuable discussion, to V. G. Larionova for help in planning the experiments, as well as to S. M. Kornechenko and V. J. Zinov for help in work with the meson beam.

*Energy of the Li^8 fragments was determined from an experimental range-energy relation obtained by V. N. Maikov in a study of photonuclear reactions, Приборы и техника эксперимента (Instrum. & Instrum. Engg.) (in press).

[1] D. H. Perkins, Phil. Mag. **40**, 601 (1949).

[2] Menon, Muirhead, and Rochat, Phil. Mag. **41**, 583 (1950).

[3] W. B. Cheston and L. J. B. Goldfarb, Phys. Rev. **78**, 683 (1950).

[4] F. L. Adelman, Phys. Rev. **85**, 249 (1952).

[5] G. Vanderhaeghe and M. Demeur, Nuovo cimento Suppl. **4**, 931 (1956).

[6] P. Ammiraju and L. M. Lederman, Nuovo cimento **4**, 283 (1956).

[7] Sens, Swanson, Telegdi, and Yovanovitch, Nuovo cimento **7**, 536 (1958).

Translated by H. Kasha
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ENERGY DEPENDENCE OF THE ASYMMETRY COEFFICIENT IN $\pi^+ \to \mu^+ \to e^+$ DECAYS FOR THE LOW ENERGY PART OF THE POSITRON SPECTRUM

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We have found earlier[1] that the asymmetry coefficient a in $\pi^+ \to \mu^+ \to e^+$ decays, taken over the whole positron spectrum in propane filling a bubble chamber, is -0.19 ± 0.03.

Recently we studied the asymmetry coefficient a′ for various parts of the positron energy spectrum. Positron energies were measured by multiple scattering.

The distribution function for positron decays, according to the four-component theory taking account of nonconservation of parity, has the form[2]

$$dN(\varepsilon, \theta) = A\left\{3(1-\varepsilon) + 2\rho\left(\frac{4}{3}\varepsilon - 1\right) - \xi\cos\theta\left[(1-\varepsilon) + 2\delta\left(\frac{4}{3}\varepsilon - 1\right)\right]\right\}\varepsilon^2\, d\varepsilon\, d\Omega,$$

where $\epsilon = E/E_{max}$ is the positron energy as a fraction of the maximum energy; ρ, ξ and δ are parameters of the theory which depend on the coupling constant. In the two-component theory $\rho = 0.75$; $-1 < \xi < +1$; $\delta = 0.75$.[3]

The existing experimental data mainly concern the determination of the constant ρ: $\rho = 0.68 \pm 0.02$;[4] $\xi = 0.8 \pm 0.15$.[5] Data on the determination of the parameter δ are few up to the present.[6]

The difference in the values of the quantity a'_{II}, calculated from the two-component theory (i.e., where $\delta = 0.75$) and the quantity a'_{IV}, calculated from the four-component theory (where $\delta > 0.75$) relative to the value a'_{II} (i.e., the quantity $|a'_{II} - a'_{IV}|/a'_{II}$) is much smaller in the high-energy part of the spectrum than in the low-energy part.

Energy interval in units $\varepsilon = E/E_{max}$	Number of positrons	Experimental value* $a'_{0-\varepsilon}$ calculated according to		Expected value of $a'_{0-\varepsilon}$ from the two-component theory according to data for the "corrected" spectra with $a = -0.19$.
		"Forward-backward" ratio	Mean cosine	
0—0.2	62	$+0.35\pm0.27$	$+0.34\pm0.25$	$+0.095$
0—0.3	183	$+0.29\pm0.16$	$+0.25\pm0.15$	$+0.08$
0—0.4	312	$+0.18\pm0.12$	$+0.14\pm0.11$	$+0.065$

*$a'_{0-\varepsilon}$ is the asymmetry coefficient for positions in the interval of energy from 0 to ε.

Because of this, and also because of the dependence of the parameter δ on the interference terms, experiments studying the quantity* $a'_{1.e.}$ afford especially sensitive tests of various variants of the theories of $\mu \rightarrow e$ decays.

Experimental data on the determination of the quantity $a'_{1.e.}$ are given in a few experimental works (see references 7 and 8).

In order to determine the quantity $a'_{1.e.}$, we used the low-energy positron tracks from 10,000 $\pi^+ \rightarrow \mu^+ \rightarrow e^+$ decays considered in reference 1.

In measuring positron energies by multiple scattering, the measurements are not affected by positron annihilation in flight (which might make the determination of $a'_{1.e.}$ incorrect because of a misleading relative transfer of part of the positrons from the region of high energies into the region of low ones). Effects from fluctuations in the energy loss by bremsstrahlung are unimportant in this method. The influence of the mean square error, which is less than 30%, in measuring energies by second differences, affects the quantity $a'_{1.e.}$ significantly less than radiative corrections[2] for bremsstrahlung.

Values of the asymmetry coefficient $a'_{1.e.}$ are given in the table for energy intervals $0-0.2\,\epsilon$; $0-0.3\,\epsilon$; $0-0.4\,\epsilon$.

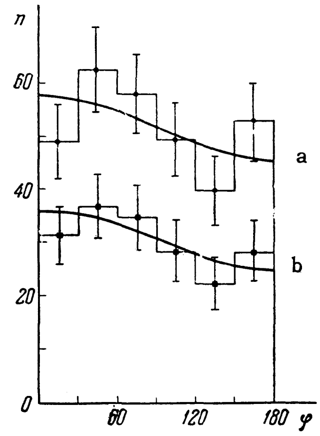
In the measurements we used positron tracks tentatively chosen by visual estimate of their energies from multiple-scattering measurements. For the positron tracks found by energy measurements to be outside of the interval from 0 to 20 Mev, the coefficient $a'_{0-\epsilon}$ was observed to decrease with increasing energy. For $\epsilon = 0.7\,E/E_{max}$ the quantity $a'_{0-\epsilon}$ was approximately zero.

The angular distribution for the positrons included in the table fits well $1 + a\cos\varphi$ law (see figure).

The error in the values of $a'_{1.e.}$ was determined from the 'forward-backward' ratio according to the formula $2.2/\sqrt{N}$, or the mean cosine according to the formula $1.98/\sqrt{N}$.

The expected value of $a'_{1.e.}$ in the two-component theory was calculated from the theoretical spectrum, 'corrected' for the effects of errors in the measured energies,[9] radiative corrections,[2] and effects of bremsstrahlung.

The measured values $a'_{1.e.}$ in the energy region up to 20 Mev indicate that the sign of the coefficient $a'_{1.e.}$ is positive. From our data the probability of a negative sign for $a'_{1.e.}$ in the energy interval from 0 to 15 Mev is less than 5%.



a – positrons of energy up to 0.4 ε. b – positrons of energy up to 0.3 ε.

Vaisenberg et al.[10] have found from measurements in photoemulsions that $a'_{0-0.3\epsilon}$ is equal to 0.14 ± 0.10 (according to the two-component theory the value of $a'_{0-0.3\epsilon}$ for this case is equal to 0.04). From our experiments, using the same method for calculating $a'_{1.e.}$, its value for the energy 0 to $0.3\,\epsilon$ interval is equal to 0.25 ± 0.15 (according to the two-component theory $a'_{0-0.3} = 0.08$). These experimental data, viewed as a whole, do not contradict the two-component theory, but agree better with the four-component theory if $\rho \approx 0.68$ and $\delta > 0.8$ are used.

To obtain a reliable experimental value for $a'_{0-\epsilon}$, it would be necessary to increase the statistical accuracy of the result.

We should like to express our gratitude to Acad. A. I. Alikhanov for suggesting this subject and for discussion of results, to A. O. Vaisenberg for discussion of a series of problems, to Prof. V. P. Dzhelepov for making it possible to use the π^+-meson beam from the synchrocyclotron of the

Joint Institute for Nuclear Research, and to A. P. Birzgal for carrying out the calculations.

*$a'_{l.e.}$ is the asymmetry coefficient for the low-energy part of the decay positron spectrum.

[1] Barmin, Kanavets, Morozov and Pershin, J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 830 (1958), Soviet Phys. JETP **7**, 573 (1958).

[2] T. Kinoshita and A. Sirlin, Phys. Rev. **107**, 593 (1957).

[3] T. D. Lee and C. N. Yang, Phys. Rev. **105**, 1671 (1957); L. D. Landau, J. Exptl. Theoret. Phys. (U.S.S.R.) **32**, 407 (1957); Soviet Phys. JETP **5**, 337 (1957).

[4] K. M. Crowe, Bull. Amer. Phys. Soc., Ser. II, **2**, 206 (1957).

[5] M. F. Kaplon, Proc. Rochester Conference, 1957.

[6] Berley, Coffin, Garwin, Lederman, and Weinrich, Phys. Rev. **106**, 835 (1957).

[7] Pless et al., Phys. Rev. **108**, 159 (1957).

[8] A. O. Vaisenberg and V. A. Smirnitskii, J. Exptl. Theoret. Phys. (U.S.S.R.) **32**, 1340 (1957); Soviet Phys. JETP **5**, 1093 (1957); J. Exptl. Theoret. Phys. (U.S.S.R.) **33**, 621 (1957); Soviet Phys. JETP **6**, 477 (1958).

[9] Bonetti, Levi-Setti, Panetti, Rossi and Tomasini, Nuovo cimento **3**, 33 (1956).

[10] Vaisenberg, Smirnitskii, Kolganova, Minervina, Pesotskaia, and Rabin, J. Exptl. Theoret. Phys. (U.S.S.R.) **35**, 645 (1958).

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RANGES OF Na^{24} *RECOIL NUCLEI AND THE MECHANISM OF CERTAIN PHOTONUCLEAR REACTIONS*

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PHOTONUCLEAR reactions at high photon energies (~100 to 200 Mev) are usually described by means of the so called "quasi-deuteron" model, according to which the reaction is represented in the form of three successive processes: (1) absorption of a gamma quantum by a pair of nucleons of the nucleus,[1] (2) intranuclear nucleon cascade produced by these nucleons,[2] and (3) evaporation of particles from the excited nucleus that is formed after the cascade.[3]

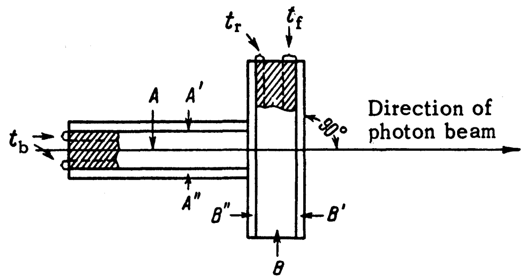

FIG. 1. Irradiation geometry. A and B – specimens; A', A", B', and B" – films to gather the recoil nuclei from the specimens; t_b – effective thickness for recoil nuclei from specimen A; t_f and t_r – effective thicknesses for recoil nuclei emerging from specimen B in the forward and reverse directions relative to the γ-quanta beam.

One of the most direct methods of verifying this model is to measure the ranges of the recoil nuclei.[4] In our experiments, we measured a quantity proportional to the range, namely the effective thickness t of the specimen for Na^{24} recoil nuclei produced by photonuclear reactions from aluminum, silicon, phosphorus, and sulphur. The value of t was determined from the expression $t = N/a_0$, where N is the number of recoil nuclei per square centimeter of a specimen whose thickness is greater than the maximum range of the recoil nuclei, while

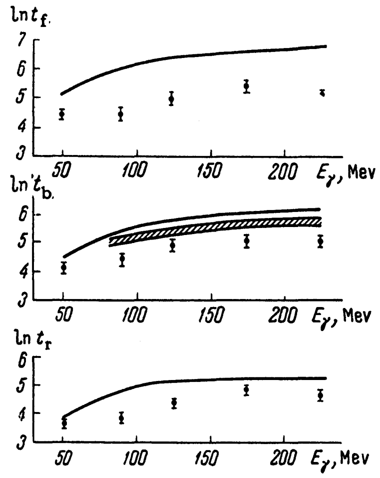

FIG. 2. Dependence of the effective thicknesses t_f, t_b, and t_r for the Na^{24} recoil nuclei, produced in the reaction Al^{27} (γ, 2pn), on the energy E_γ of the gamma quanta. ● – experimental values of the mean effective thickness in the photon-energy intervals (35 – 80, 80 – 100, 100 – 150, 150 – 200, and 200 – 260 Mev). Solid curve – calculated from the compound-nucleus theory. Cross-hatched curve – calculated by the "quasi-deuteron" model.

ERRATA TO VOLUME 7

Page	Reads	Should Read
533, title	Nuclear magnetic moments of Sr^{87} and Mg^{95}	Nuclear magnetic moments of Sr^{87}
645 Eq. (1)	$\ldots + \varkappa \sqrt{j_0(j_0+1)}$	$\ldots - \varkappa \sqrt{j_0(j_0+1)}$
647 Eq. (11)	$(L+1)\lvert B_L^- \rvert^2 - L \lvert B_L^+ \rvert^2$	$L(L+1)\left[\lvert B_L^- \rvert^2 - \lvert B_L^+ \rvert^2\right]$
894 Eq. (12)	$\varepsilon_{11} = 1 - \sum \frac{\cdots}{\sqrt{\pi/\mu}}$	$\varepsilon_{11} = 1 - \sum \frac{\cdots}{\sqrt{\pi}\,\mu}$
897 Eq. (45)	$\sqrt{\pi/2}$	$\sqrt{\pi/8}$
979 Table II, heading	$\lvert E_\gamma > 50$ **Mev** $\lvert E_\gamma > 50$ **Mev**	$\lvert E_\gamma < 50$ **Mev** $\lvert E_\gamma > 50$ **Mev**
1023 Figure caption		a) $\omega < \omega_H$, b) $\omega > \omega_H$
1123 Eq. (2)	$\Gamma = \mu_2/\mu_1$	$\Gamma = \mu_2/\mu_1,\ \mu_\perp = (\mu_1^2 - \mu_2^2)/\mu_1$

ERRATA TO VOLUME 8

Page	Reads	Should Read
375 Figure caption	a) positrons of energy up to 0.4 ϵ, b) positrons of energy up to 0.3 ϵ.	a) positrons of energy up to 0.3 ϵ, b) positrons of energy up to 0.4 ϵ.
816 Beginning of Eq. (8)	$I_2^5 = (4\pi)^2 \ldots$	$I_2^2 = (4\pi)^5 \ldots$