EXPERIMENTAL DETERMINATION OF THE RELATIVE PROBABILITIES FOR VARIOUS BRANCHES OF K_2^0 DECAY

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The following relative probabilities for lepton and nonlepton decays have been derived from an analysis of 9400 V^0 events due to the decay of long-lived K^0 mesons:

$$W(K_{e3}^0) = (49.8 \pm 5.2)\,\%, \quad W(K_{\mu3}^0) = (33.5 \pm 5.5)\,\%,$$
$$W(K_2^0 \to \pi^+ + \pi^- + \pi^0) = (16.7 \pm 1.6)\,\%, \quad W(K_2^0 \to 3\pi^0) = (31^{+7}_{-6})\,\%.$$

Within the experimental errors, the results are in good agreement with the selection rule $\Delta I = 1/2$ for the isotopic spin.

MEASUREMENT of the relative probabilities of lepton and nonlepton decays of K mesons is of particular interest from the point of view of checking the selection rule $\Delta I = 1/2$ with respect to isotopic spin. In this case, for nonlepton decays it is possible in principle to measure the relative intensities of the transitions with isotopic spin change $\Delta I = 3/2$ or $\Delta I = 5/2$, knowledge of which is essential for the establishment of the mechanism for violating the selection rule $\Delta I = 1/2$, namely to determine whether this violation is due to virtual photons or whether it is inherent in the nature of weak interactions. In this investigation we have measured the relative probabilities of the K_2^0-meson decays

$$\begin{aligned} K_2^0 &\to \pi^\pm + e^\mp + \nu \\ &\to \pi^\pm + \mu^\mp + \nu \\ &\to \pi^+ + \pi^- + \pi^0 \\ &\to \pi^0 + \pi^0 + \pi^0 \end{aligned}$$

on the basis of reducing 9500 V^0 events from K_2^0-meson decay. These events were registered by cloud chambers placed in a magnetic field in beams of the neutral particles from the proton synchrotron of the Joint Institute for Nuclear Research. The experimental setup was described in detail earlier [1,2].

1. RELATIVE PROBABILITY OF K_{e3}^0 DECAY

The relative probability of the K_{e3}^0 decay was first determined at JINR in 1960 with the aid of a cloud chamber of 400 mm diameter, placed in a magnetic field [1]. In that investigation, the K_{e3}^0 decays were identified on the basis of measurement of the momentum lost by the decay particles as they passed through a lead plate 5.8 g/cm² thick placed in a number of exposures in the middle of the fiducial volume of the chamber. With further progress in research on the properties of K_2^0 mesons at the JINR, more accurate values were obtained for the relative probability of the K_{e3}^0 decay[2)] with a one-meter cloud chamber in a magnetic field, using the same procedure for selecting the K_{e3}^0 decays as in [1].

In the case of the one-meter chamber (for which the average absolute error in the measurement of the loss of momentum by the decay particles is 17%), we used as the minimum momentum loss in the electron section the value $\Delta p/p = 50\%$, that is, the particles for which $\Delta p/p > 50\%$ and passing through the plate were classified as electrons. The pions and muons were excluded from the particles with momentum loss exceeding 50% by comparing the measured and the calculated ionization losses. Since the pions and muons capable of imitating electrons at the indicated minimum value of the momentum loss have a momentum not larger than 100 MeV/c, we used as an additional identification criterion measurement of the density of the track of the passing particle ahead and past the plate.

To ensure the best conditions for the registration of the passage of decay particles through the plate and to enhance the reliability of the momen-

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[2)]The probabilities determined from part of the material obtained with the one-meter chamber were published in [3,4].

tum-loss measurement, we selected only such V^0 events in which: a) the track length of the passing particles not less than 10 cm ahead of the plate and not less than 5 cm past the plate; b) the sag of the track projection on the photograph plane is $\Sigma > 0.06$ mm; c) the vertex of the V^0 event is located in a well-illuminated part of the fiducial volume of the chamber (15 cm high). The use of the foregoing minimal values of lengths and sags limited the error in the measurement of the momentum lost by the passing particles to the aforementioned 17%.

To determine the total number of K_{e3}^0 decays among the V^0 events in which one or both particles pass through the lead plate, a correction for the passage of electrons with momentum loss $\Delta p/p > 50\%$ was introduced into the number of passages of electrons with momentum loss $\Delta p/p \leq 50\%$, as well as a correction for passages accompanied by showers in which the electron energy does not exceed 8 MeV. Introduction of the second correction was necessitated by the fact that the illumination and background conditions near the lead plate were such that only shower electrons with energy exceeding 8 MeV were reliably registered.

In introducing the first correction, we used the formula obtained by Eyges[5] for the scatter of the electron radiation-energy loss. We assumed for the unit radiation length in lead the value $X_0 = 6.4$ g/cm^2, calculated by Dovzhenko and Pomanskiĭ[6] with allowance for the latest data on the cross sections for electron bremsstrahlung and pair production by photons. This value of the radiation unit length was assumed to be accurate to 6%. It was found as a result, with allowance for the criteria for the V^0-event selection, that the fraction of the passages of electrons with momentum $\Delta p/p > 50\%$ (averaged over the path lengths of these particles in the lead plate) is $(74 \pm 4)\%$.

The second correction was introduced in accordance with the experiments of d'Andlau[7], in which it was established that the fraction of showers with electron energies $E \leq 8$ MeV is 4% for electrons with initial energy $E = 300$ MeV and for a plate of thickness of one X_0 unit. Inasmuch as the average energy of the passing electrons in our experiment differed little from $E_0 = 300$ MeV, and the plate thickness was close to one X_0 unit, the use the data from the cited paper entailed no noticeable error.

The net result of the measurement of the V^0 events and of the introduction of the corrections was as follows: 1) The total number of V^0 events with passage of one or both decay particles through the plate is $N = 1095$. 2) The number of passing electrons, with allowance for corrections for a momentum loss $\Delta p/p \leq 50\%$ and for showers with particle energies $E \leq 8$ MeV is $n = 191.4$.

Substitution of these data into the formula

$$W = \frac{n(P_{e1}+P_{\pi1})\{(P_{\mu2}+P_{\pi2})+W(3\pi)[(P_{\mu3}+P_{\pi3})-(P_{\mu2}+P_{\pi2})]\}}{[NP_{e1}-n(P_{e1}+P_{\pi1})](P_{e1}+P_{\pi1})+n(P_{e1}+P_{\pi1})(P_{\mu2}+P_{\pi2})}$$

yields for the relative probability of the K_{e3}^0 decay a value

$$\frac{W(K_2^0 \to \pi^\pm + e^\mp + \nu)}{W(K_2^0 \to \text{ charged products })} = (51 \pm 6)\,\%.$$

In the formula, P_{e1} and $P_{\pi1}$ are the calculated probabilities of the passage of electrons and pions from the K_{e3}^0 decay through the plate, which are equal to respectively 14.90 and 19.12%; $P_{\mu2}$ and $P_{\pi2}$ are the calculated probabilities of the passage of muons and pions from the $K_{\mu3}^0$ decay, equal respectively to 22.57 and 24.35%; $P_{3\pi}$ is the calculated probability of the passage of pions from the decay $K_2^0 \to \pi^+ + \pi^- + \pi^0$, amounting to 32.90%, and $W_{3\pi}$ is the relative probability of this decay.

The calculated probabilities of the passage of decay particles through the plate were obtained on the basis of 3000 tests in each case[3)]. The reduced error in the determination of the probability includes, besides the statistical deviations, also the inaccuracies connected with the introduction of the corrections and the uncertainty with which the probability of the charged $K_{3\pi}^0$ decay was measured, the latter being according to our data $(16.7 \pm 1.6)\%$.

The relative probability of the K_{e3}^0 decay, obtained in analogous fashion from the 400 mm cloud chamber, is 0.46 ± 0.11. The mean-weighted value of the relative probability is

$$W(K_{e3}^0) = (49.8 \pm 5.2)\,\%.$$

2. RELATIVE PROBABILITY OF THE DECAY $K_2^0 \to \pi^+ + \pi^- + \pi^0$

To determine the probability of the decay $K_2^0 \to \pi^+ + \pi^- + \pi^0$ we used a statistical method of dividing the branches of the decay (proposed in the paper of Astier et al.[8]), in which it is not necessary to identify the decay particles. This method is based on reconciling the calculated distributions

[3)] All the calculations of the theoretical characteristics of the decays were made by the Monte Carlo method with allowance for the conditions for selecting the V^0 events and for the energy spectrum of the K_2^0 mesons.

of the V^0 events with respect to the parameter

$$E_5' = (M_K^2 - m_{\pi^0}^2 + M_t^2)/2\sqrt{M_t^2 - p_{N\perp}^2}$$

(where M_t is the effective mass of the charged decay products, calculated under the assumption that all the decay particles are pions; $p_{N\perp}$ is the perpendicular component of the momentum of the neutral decay particle) with the corresponding experimental distribution by minimizing the function χ^2. The parameter E'_5 is the energy of the decaying K_2^0 meson in a system in which the longitudinal component of the momentum of the charged decay particles is zero.

In this case we used for the analysis only V^0 events whose vertices are located in a well-illuminated volume of the chamber (12 cm high), and in which the lengths of the track projections on the plane of the photograph are $l \geq 10$ cm, and the dip angles of the tracks are $\alpha \leq 60°$. The calculated efficiencies of such a selection for the decays K_{e3}^0, $K_{\mu 3}^0$, and $K_2^0 \to \pi^+ + \pi^- + \pi^0$ are respectively 0.249, 0.330, and 0.464. The total number of selected events is 1402. Their distribution with respect to the parameter E'_5 is shown in Fig. 1. The dashed line in this figure shows the calculated distribution for the case when the relative probability of the decay $W(K_2^0 \to \pi^+ + \pi^- + \pi^0)$ is 16.2%. The calculated distribution is the sum of the distributions for the K_{e3}^0, $K_{\mu 3}^0$, and $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decays. In plotting the summary distribution, we assumed that the ratio of the probabilities of K_{e3}^0 and $K_{\mu 3}^0$ decays is 1:0.65.

The solid line of Fig. 2 shows the experimental energy spectrum of the π^0 mesons; this spectrum was obtained from V^0 events with $E'_5 > 493$ MeV and was corrected by calculation for the contribution from the K_{e3}^0 and $K_{\mu 3}^0$ decays. As seen from the figure (the dashed line in which shows the π^0-meson spectrum for a constant matrix element), the experimental spectrum differs noticeably from the calculated one. If the ratio between the frequencies of the events in the experimental (ΔN) and the calculated ($\Delta\Phi$) spectra is represented in the form

$$\Delta N = (1 + \alpha T_{\pi^0}/M_K)\,\Delta\Phi,$$

where T_{π^0} is the kinetic energy of the π^0 meson, then we get for the coefficient $\alpha = -7.8 \pm 0.9$.

To take into account the deviation of the matrix element for the $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decay from a constant quantity, we used the following procedure to calculate the distribution with respect to the parameter E'_5. Assuming the matrix element to be constant, we calculated the distributions corresponding to π^0-meson kinetic-energy intervals of width $\Delta E = 10$ MeV, starting with zero energy. These distributions were then all summed with weights equal to the weights of the corresponding energy intervals in the experimental spectrum of the π^0 mesons. In calculating the distribution for the lepton decays, we assumed the vector variant of the interaction. The calculated distributions for the K_{e3}^0, $K_{\mu 3}$, and $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decays were obtained on the basis of 1250, 830, and 625 separate tests, respectively; in the distributions we took into account the average experimental error in the measurement of the parameter E'_5. The dependence of the function χ^2 on the relative decay probability $W(K_2^0 \to \pi^+ + \pi^- + \pi^0)$ is of the form

$W(K^0_2 \to \pi^+ + \pi^- + \pi^0)$, %:	10.0	13.75	15.0	16.25	17.50	18.75
χ^2:	44.7	21.3	16.2	15.0	16.0	17.8

The expected value of χ^2 is 10.

The minimum of χ^2 corresponds to a probability of 16.4%. The obtained probability is somewhat undervalued because the scattering of the K_2^0 mesons prior to the decay act "converts" some of

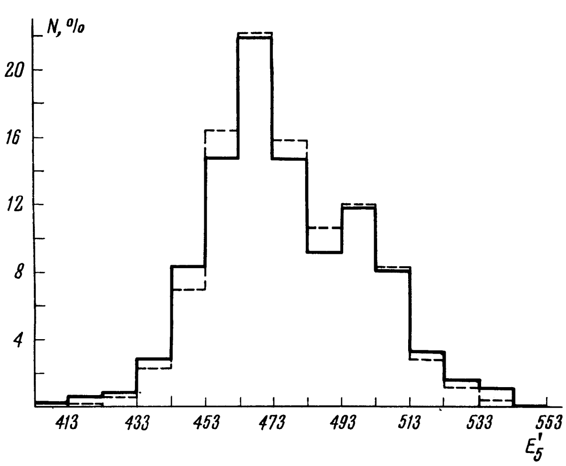

FIG. 1. Experimental distribution of V events with respect to the parameter E'_5. The dashed line shows the calculated distribution for $W(K_2^0 \to \pi^+ + \pi^- + \pi^0) = 16.2\%$.

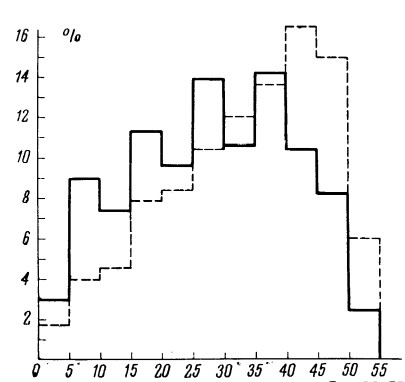

FIG. 2. Energy spectrum of π^0 mesons; dashed – calculated distribution.

the $K_2^0 \to \pi^+ + \pi^- + \pi$ decays into K_{e3}^0 and $K_{\mu3}^0$ decays. This decrease amounts to about 1.5–2%. The corrected probability is

$$\frac{W(K_2^0 \to \pi^+ + \pi^- + \pi^0)}{W(K_2^0 \to \text{ charged products })} = (16.7 \pm 1.6)\,\%.$$

The reduced error in the determination of the probability includes the statistical deviations and the uncertainty connected with the inaccuracy with which the average error in the measurement of the parameter E'_5 is determined. Since the distributions with respect to the parameter E'_5 for the K_{e3}^0 and $K_{\mu3}^0$ decays are close to each other, the ratio of the probabilities of these decays has practically no effect on the probability of the $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decay. Therefore the obtained value of the probability at a given measurement error does not depend on the assumption made by us concerning the numerical value of the probability ratio of the lepton decays.

The probability of the $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decay was determined somewhat earlier in similar fashion by a parallel group at our institute[9]. Compared with their work, we used more rigorous criteria for the selection of the V^0 events and took additional account of the dependence of the matrix element of the investigated decay on the π^0-meson energy.

3. RELATIVE PROBABILITY OF $K_{\mu3}^0$ DECAY

The $K_{\mu3}^0$-decay probability was determined as the complement the measured summary probabilities of the K_{e3}^0 and $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decays to unity. As a result

$$\frac{W(K_{\mu3}^0)}{W(K_2^0 \to \text{ charged products })} = (33.5 \pm 5.5)\,\%.$$

Thus, the lepton-decay probability ratio measured in our experiment amounts to

$$W(K_{\mu3}^0)/W(K_{e3}^0) = 0.67 \pm 0.13.$$

The values of the parameter $\xi = f_-/f_+$ (where f_- and f_+ are the strong-interaction form factors for the lepton decays), determined from the given probability ratio, are

$$\xi_1 = 0.2^{+0.8}_{-1.2}, \qquad \xi_2 = -7.0^{+1.1}_{-0.9}.$$

4. RELATIVE PROBABILITY OF THE $K_2^0 \to 3\pi^0$ DECAY

The first experimental evidence[1] for the existence of the $K_2^0 \to 3\pi^0$ decay was obtained at JINR with the aid of the 400 mm cloud chamber. At that time, four electron-positron pairs were registered, the origin of which was difficult to attribute to processes other than the decay

$$K_2^0 \to \pi^0 + \pi^0 + \pi^0 \to \gamma + e^+ + e^-.$$

Later, when these investigations were continued with the aid of the one-meter cloud chamber, observation of 11 electron-positron pairs proved the existence of the decay under consideration and yielded an estimate of its relative probability[10].

On completing the reduction of the experimental data, we registered 29 electron-positron pairs satisfying the following selection criteria: a) The momentum of one of the electrons of the pair was $p \le 80$ MeV/c, and that of the second electron $p \le 100$ MeV/c. b) The lengths of the projections of the pair tracks on the plane of the photograph were $l \ge 40$ mm. c) The aperture angle of the pair was $\omega \le 70°$. d) The pair emergence angle was $\theta_t > 20°$. e) The dip angle of the pair momentum direction was $\alpha_t \le 45°$.

In order to ensure good conditions for the measurement of the relative density of the V^0-event tracks, the height of the volume in which we registered the pairs was taken to be 12 cm. In addition, regions 50 mm thick adjacent to the side walls and to the lead plate were not included in the registration volume. We found 7250 V^0 events within this separated volume. The identification of the electrons by measuring the track density is described in detail in a paper by Anikina et al.[10] According to the calculation, the relative fraction of the pairs satisfying the selection criteria amounts to 0.396 for the one-meter chamber. The calculation was made on the basis of the pair distribution function obtained by Kroll and Wada[11].

Figures 3 and 4 show a comparison of the experimental pair distribution with respect to the square of the ratio of the effective masses of the pair to the mass of the π^0 meson and with respect to the aperture angle, with the corresponding cal-

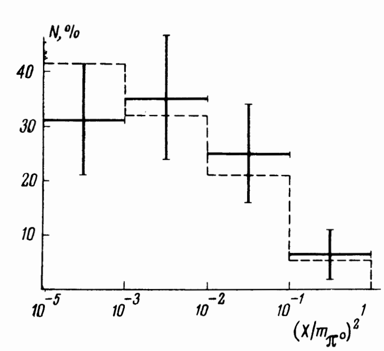

FIG. 3. Distribution of selected pairs with respect to the parameter $(X/m_{\pi^0})^2$; dashed – calculated distribution.

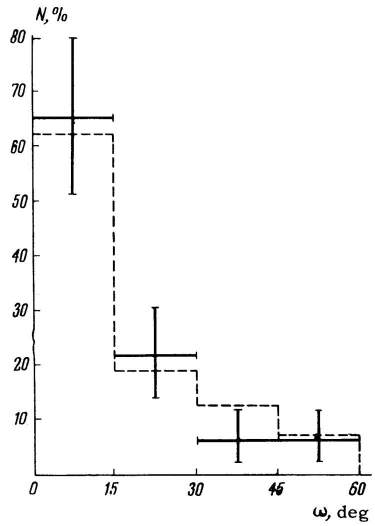

FIG. 4. Distribution of selected pairs with respect to the aperture angle; dashed – calculated distribution.

culated distributions for Dalitz pairs from the $K_2^0 \to 3\pi^0$ decay. The effective mass X of the pair is equal to

$$X = [(E_+ + E_-)^2 - (\mathbf{p}_+ + \mathbf{p}_-)^2]^{1/2},$$

where E_+, $\mathbf{p}_+$ and E_-, $\mathbf{p}_-$ are the energy and momentum of the positron and electron. To increase the statistics somewhat, the experimental distribution includes three pairs not satisfying the selection criteria with respect to the dip angle and the location of the pair vertex. Calculation has shown that these criteria have practically no influence on the distributions in question. In view of the fact that the experimental error exceeds by several times the calculation errors, Figs. 3 and 4 show only the experimental errors. As seen from Figs. 3 and 4, there is perfectly satisfactory agreement between the experimental and theoretical distributions. This agreement indicates (see [10]) that the contribution made to the selected pairs by the external conversion pairs is small. The calculated estimate of this contribution is 13.6%.

Table I shows a comparison of the experimental[4)] and distributions of the pairs with respect to a parameter Y, defined as

$$Y = |E_+ - E_-| / p_t,$$

where p_t is the absolute value of the pair momentum.

Inasmuch as the distributions of the Dalitz pairs and of the external-conversion pairs with respect

Table I

ΔY	Number of pairs, %	
	Experiment	Calculation
0,0—0.2	41.6±9.4	24.8
0,2—0.4	25.0±7.3	23.7
0,4—0.6	25,0±7.3	20.9
0.6—0.8	6.3±3.6	17.4
0.8—1,0	2.1±2.1	13.2

to the parameter Y are close to each other (unlike the distributions with respect to the effective mass and the aperture angle), this comparison cannot be used to establish the nature of the selected pairs. However, under the conditions of our experiment, this comparison turns out to be very useful for the determination of the registration efficiency of the Dalitz pairs by visual scanning of the photographs, relative to the efficiency of registration of the V^0 events from the charged K_2^0-meson decays. It is seen from the table that the experimental and calculated distributions do not agree in this case. Indeed, if the experimental distribution is broken up into two intervals, $\Delta Y_1 = 0.0-0.6$ and $\Delta Y_2 = 0.6-1.0$, then the number of pairs in them differ from the calculated ones by more than three standard deviations.

Since the theoretical distribution with respect to the parameter Y for the Dalitz pairs from the $\pi^0 \to \gamma + e^+ + e^-$ decay agrees well with the experimental distribution obtained by Samios et al.[13] on the basis of registration of more than 3000 pairs, it must be concluded that the observed discrepancy between the distributions under the conditions of our experiment is connected with the small efficiency of registering such pairs in which one of the particles has a small momentum. The reason for losing count of such pairs is obviously the presence of a background of extraneous particles in the chamber[5)]. As seen from Table II, the missing of pairs in which one of the particles has a small momentum has practically no effect on the distribution of the pairs with respect to the effective mass and the aperture angle. In the second and fourth columns of the table are given the calculated distributions (shown in Figs. 3 and 4) and in the third and sixth columns are given the distributions obtained from them by eliminating all the pairs for which the momentum of one of the particles does not exceed 15 MeV/c.

[4)]The experimental distribution includes, besides the pairs listed in Table I, also 16 pairs considered in the paper by Anikina et al.[12]

[5)]The low efficiency of Dalitz-pair registration, for pairs in which the momentum of one of the particles is small, was observed earlier in [14-16].

Table II

$\Delta\left(\frac{X}{m_{\pi^0}}\right)^2$	Number of pairs, %		$\Delta\omega$, deg	Number of pairs, %	
	$p>0$	$p>15$ MeV/c		$p>0$	$p>15$ MeV/c
10^{-5}—10^{-3}	41.3	40.3	0—15	62.2	70.2
10^{-3}—10^{-2}	32.1	33.7	15—30	18.9	17.9
10^{-2}—10^{-1}	21.2	19.4	30—45	12.5	11.5
10^{-1}—1,0	5.4	6.6	45—70	6.4	1.6

Further confirmation of the fact that the indicated discrepancy in the pair distribution with respect to the parameter Y actually does take place and is not due to calculation errors or to the insufficient statistics, is the observation of a similar picture in the distribution of 36 external conversion pairs and 17 Dalitz pairs from the four-prong decays[6)]

$$K_2^0 \to \pi^+ + \pi^- + \pi^0 \begin{smallmatrix}\nearrow \gamma \\ \searrow e^+ + e^-.\end{smallmatrix}$$

Therefore the assumption which we made above in determining the probability of the $K_2^0 \to 3\pi^0$ decay (in [10,12]), that the registration efficiencies are the same for Dalitz pairs and V^0 events from charged K_2^0-meson decays, is incorrect.

In order to introduce a correction for the indicated difference in the registration efficiencies, we assume that in the interval $\Delta Y = 0.0$—0.6, where there is no patent disparity between the experimental and calculated distributions, the probability of Dalitz-pair registration is equal to the probability of registration of V^0 events from charged K_2^0-meson decays. The justification for such a conclusion is the fact that the probability of registering V^0 events, obtained from results of independent scannings and classified during the preliminary (visual) identification as "similar" to Dalitz pairs (among which there actually are no events with particle momenta smaller than 40 MeV/c), turned out, within the limits of error, to be equal to the efficiency of registration of the remaining V^0 events. The correction introduced in this manner leads to an increase in the number of Dalitz pairs by a factor $1.32^{+0.10}_{-0.07}$. This error in the introduction of the corrections takes into account the calculation errors, and also the possibility of the fact that the limit of the region within which the efficiency of Dalitz-pair registration is the same as the efficiency of the registration of the remaining V^0 events may be situated near Y = 0.4. The relative probability

Table III

Decay branch	Relative probability, %	Absolute probability, 10^6 sec^{-1}
K_{e3}^0	48.7±5 [18] 49.8±5.2	7.7 ±1.2 [19]
$K_{\mu 3}^0$	35.6±7 [18] 33.5±5.5	— —
$K_2^0 \to \pi^+ + \pi^- + \pi^0$	$18.5^{+3.8}_{-3.4}$[8] 15.7±3.0[18] 15.1±2.0[22] 15.9±1.5[24] 19.4±2.3[9] 16.2±1.5[25] 17.8±1.7[27] 14.4±0.04[26] 16.7±1.6	2.75±0.60[20] 3,26±0.77[21] $2.62^{+0,28}_{-0,27}$ [23] — — — — — —
$K_2^0 \to 3\pi^0$	28±8 [12] 20±6 [29] 31^{+7}_{-6}	5.55±0.44[28] $5.22^{+1,03}_{-0,84}$ [23] —
$K_{e3}^0 + K_{\mu 3}^0 + (K_2^0 \to \pi^+ + \pi^- + \pi^0)$		15.8±1.9[30]
$K_{e3}^0 + K_{\mu 3}^0 + (K_2^0 \to 3\pi^0)$		{20.8±2.0[30] {$16.4^{+4.2}_{-3,2}$ [31] {19.0±2.0[32]

determined on the basis of observation of 29 Dalitz pairs, with allowance for correction for the registration efficiency, is[7)]

$$\frac{W(K_2^0 \to 3\pi^0)}{W(K_2^0 \to \text{ charged products })} = (31^{+7}_{-6})\,\%.$$

5. DISCUSSION OF RESULTS

The experimental data on the relative and absolute probabilities of the different branches of the K_2^0-meson decay, contained in the literature at the time when this article is written are summarized in Table III. To complete the picture, the table includes also the results of the three latest and most accurate measurements of the absolute probability of K_2^0 decay. The mean-weighted absolute probability of K_2^0 decay is $\Gamma(K_2^0) = (19.4 \pm 1.3) \times 10^6$ sec^{-1}. The corresponding average lifetime of the K_2^0 meson is $\tau(K_2^0) = (5.2 \pm 0.4) \times 10^{-8}$ sec. We see from the table that in our work, compared with work by others, we obtained the most complete data on the relative probabilities of different branches of the K_2^0 decay, and that they are in good agreement with analogous results of others.

The first column of Table IV lists the relative

6)For details concerning the pair registration efficiency see [17].

7)In determining the probability we took account of the fact that the fraction of the selected Dalitz pairs is somewhat lower for the 400 mm cloud chamber than for the one-meter chamber.

Table IV

Decay branch	Experiment		Calculation	
	Relative probability, %	Relative probability, % 10^6 сек$^{-1}$	Relative probability, %	Absolute probability, 10^6 sec^{-1}
K^0_{e3}	49.8±5.2	7,5±1.1	49.1±3.2	7.7±0.5
$K^0_{\mu3}$	33.5±5.5	4.7±1.0	31.4±5.2	4.9±0.8
$K^0_2\to\pi^++\pi^-+\pi^0$	16.7±1.6	2.5±0.4	19.5±1.9	3.0±0.3
$K\to 3\pi^0$	31.0^{+7}_{-6}	4.5±1.6	35.6±3.7	5.6±0.6

K_2^0-decay probabilities measured by us, and the second column lists the absolute probabilities of the same decays, calculated from the data of the first column using the aforementioned average lifetime of the K_2^0 mesons. The third and fourth columns give the relative and absolute probabilities of the K_2^0 decays, calculated[8)] on the basis of the rule $\Delta I = 1/2$ from the relative probabilities of K^+ decays[33] using an average K^+-meson lifetime $\tau(K^+) = (1.224 \pm 0.013) \times 10^{-8}$ sec.

From a comparison of the experimental and calculated data it follows that, within the limits of experimental error, the selection rule $\Delta I = 1/2$ is well satisfied for both lepton and nonlepton decays. In view of the fact that the calculated values of the probabilities for the $K_2^0 \to 3\pi^0$ decay were obtained from the ratio

$$W(K_2^0\to 3\pi^0)/W(K_2^0\to\pi^+ + \pi^- + \pi^0) = 1.83,$$

which holds true for the case when transitions take place only to a fully symmetrical state with isotopic spin $J = 1$, and which is not sensitive to an admixture of transitions with $\Delta I = 3/2$, the agreement between the experimental and calculated probabilities must be regarded in this case as a confirmation of the well known fact that the fully symmetric state $I = 1$ predominates in the final state of three decay pions.

The experimentally obtained value of the parameter α, which describes in linear approximation the spectrum of the π^0 mesons in the $K_2^0 \to \pi^+ + \pi^- + \pi^0$ decay, agrees well with other determinations[9,18,22,34,35,26,27] of this parameter, and agrees also (in accordance with the requirement of the selection rule $\Delta I = 1/2$) within the limits of errors with its value for the spectrum of the π^+ mesons in the $K^+ \to \pi^0 + \pi^0 + \pi^+$ decay[36–38].

For nonlepton decays, the possible value of J_3, the amplitude of the transition with change of isotopic spin by $\Delta I = 3/2$ (taken from the ratio to the amplitude of the transition with $\Delta I = 1/2$) is, according to our data,

$$\operatorname{Re} J_3 = \frac{2\Gamma(K^+\to\pi^0+\pi^0+\pi^+) - 0{,}97\Gamma(K_2^0\to\pi^+ + \pi^- + \pi^0)}{4\Gamma(K^+\to\pi^0+\pi^0+\pi^+) + 0.97\Gamma(K_2^0\to\pi^+ + \pi^- + \pi^0)} = 0.04 \pm 0.04.$$

This estimate of the admixture of transitions with $\Delta I = 3/2$ was obtained in an approximation in which it is assumed that transitions with $\Delta I = 1/2$ to a fully symmetrical state with isotopic spin $I = 1$ predominate; however, transitions with $\Delta I = 3/2$ can proceed also to non-symmetrical states with $I = 1$.

It is obvious that, owing to the very large uncertainty, the foregoing estimate can determine only the order of magnitude of the amplitude of the transition with $\Delta I = 3/2$, which apparently does not exceed 4–5%. However, it is necessary to approach this estimate with a certain caution, owing to the fact that it has been obtained under the assumption of CP-invariance of the decay interaction. On the other hand, the available experimental data[39,40,23] on the time dependence of lepton and nonlepton decays of K^0 mesons does not exclude fully, within the limits of errors, the possibility of a noticeable violation of CP-invariance in the indicated decays.

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[8)] In calculating the probability we introduced corrections for the difference in the statistical weights.

[1] D. V. Neagu, É. O. Okonov, N. I. Petrov, A. M. Rozanova, and V. A. Rusakov, Zh. Eksp. Teor. Fiz. **40**, 1618 (1961) [Sov. Phys.-JETP **13**, 1138 (1961)].

[2] D. M. Kotlyarevskiĭ, A. N. Mestvirishvili, D. Neagu, É. O. Okonov, N. I. Petrov, V. A. Rusakov, L. V. Chkhaidze, and Wu Tsung-fan, Yad. Fiz. **1**, 1035 (1965) [Sov. J. Nuc. Phys. **1**, 738 (1965)].

[3] G. N. Vardenga, D. M. Kotlyarevskiĭ, A. N. Mestvirishvili, D. V. Neagu, É. O. Okonov, N. I. Petrov, V. A. Rusakov, and Wu Tsung-fan, JINR Preprint R-1920 (1964).

[4] A. N. Mestvirishvili, D. Neagu, N. I. Petrov, V. A. Rusakov, and Wu Tsung-fan, JINR Preprint P-2449 (1965).

[5] L. Eyges, Phys. Rev. **76**, 264 (1949).

[6] O. I. Dovzhenko and A. A. Pomanskiĭ, Zh. Eksp. Teor. Fiz. **45**, 268 (1963) [Sov. Phys.-JETP **18**, 187 (1964)].

[7] Ch. A. d'Andlau, J. phys. et radium **16**, 176 (1955); Nuovo Cimento **12**, 589 (1954).

[8] A. Astier, L. Blaskovic, M. M. De Cuorreges

et al., Proc. of the Aix-en-Provence Intern. Conf. on Elementary Particles (1961), Centre d'Etudes Nucl. Saclay, Seine et Oise (1961), p. 227.

[9] M. Kh. Anikina, G. N. Vardenga, M. S. Zhuravleva, et al., JINR Preprint R-2065 (1965).

[10] M. Kh. Anikina, M. S. Zhuravleva, D. M. Kotlyarevskiĭ, et al., Zh. Eksp. Teor. Fiz. **46**, 59 (1964) [Sov. Phys.-JETP **19**, 42 (1965)].

[11] N. Kroll and W. Wada, Phys. Rev. **98**, 1355 (1955).

[12] M. Kh. Anikina, M. S. Zhuravleva, D. M. Kotlyarevskiĭ, et al., JINR Preprint R-2090 (1965).

[13] N. P. Samios, R. Plano, A. Prodell, M. Schwartz, and J. Steinberger, Phys. Rev. **126**, 1844 (1962).

[14] B. N. Anand, Proc. Roy. Soc. **A220**, 183 (1953).

[15] Yu. N. Budagov, S. Viktor, V. P. Dzhelepov, P. F. Ermolov, and V. I. Moskalev, Zh. Eksp. Teor. Fiz. **38**, 1047 (1960) [Sov. Phys.-JETP **11**, 755 (1960)].

[16] C. P. Sargent, R. Cornelius, M. Rinehart, L. M. Lederman, K. Rogers, Phys. Rev. **98**, 1349 (1955).

[17] A. Mestvirishvili, D. Neagu, N. Petrov, V. Rusakov, and Wu Tsung-fan, JINR Preprint R-2450 (1965).

[18] D. Luers, I. S. Mittra, W. Willis, and S. S. Yamamoto, Phys. Rev. **133**, B1276 (1964).

[19] B. Aubert, L. Behr, J. P. Lowgs, P. Mittner, and C. Pascaud, Proc. XII Int, Conf. on High-energy Physics, V. 2, Atomizdat, 1966, p. 110.

[20] L. Behr, B. Aubert, and Y. Brisson et al., ibid. p. 112.

[21] J. A. Anderson, F. S. Crawford, K. L. Goldly, et al., Phys. Rev. Lett. **14**, 475 (1965).

[22] R. K. Adair and L. R. Leipuner, Phys. Lett. **12**, 167 (1964).

[23] L. Behr, Y. Brisson, and P. Petlay, et al., Phys. Lett. **22**, 540 (1966).

[24] P. Astburg, A. Michelini, and C. Verkerk et al., Phys. Lett. **16**, 175 (1965).

[25] C. J. B. Hawkins, Phys. Rev. Lett. **21**, 238 (1966).

[26] H. W. K. Hopkins, T. C. Bakon, and F. R. Eisler, Proc. Intern. Conf. on Weak Interaction, Argonne, (1965), p. 67.

[27] P. Cuidoni, V. Barnes, and H. W. Foelshe et al., Proc. Intern. Conf. on Weak Interaction, Argonne, (1965), p. 49.

[28] Y. Brisson, L. Behr, and P. Petian et al., op. cit. [19], p. 113.

[29] A. Aleksanyan, A. Alikhanyan, A. Gal'per, et al., Preprint, Lebedev Phys. Inst. A-75, Moscow, 1964.

[30] L. Auerbach, K. Lande, A. K. Mann et al., Phys. Rev. Lett. **14**, 192 (1965).

[31] P. Astburg, A. Michelini, and C. Verkerk et al., Phys. Lett. **18**, 178 (1965).

[32] T. Fujii, J. Jovannovich, and F. Turkot et al., op. cit. [19], p. 149.

[33] S. Francis, F. S. Shaklee, G. I. Jensen, B. P. Roe, and D. Sinclair, Phys. Rev. **136**, B1423 (1964).

[34] A. Abashian, R. J. Abrams, and I. W. Carpenter et al., Phys. Rev. Lett. **13**, 243 (1964).

[35] L. Behr, Y. Brisson, and P. Petlay et al., Phys. Lett. **22**, 540 (1966).

[36] G. Gracomelli, D. Monti, G. Quareni, A. Quareni-Vignudelli, W. Puschel, and J. Tietge, Phys. Lett. **3**, 346 (1963).

[37] G. E. Kalmus, Phys. Rev. Lett. **13**, 99 (1964).

[38] V. Bisi, G. Borreani, and R. Cester et al., Nuovo Cimento **35**, 768 (1965).

[39] B. Aubert, L. Behr, F. L. Canavan, et al., Phys. Lett. **17**, 59 (1965).

[40] M. Baldo-Ceolin, E. Calimati, S. Giampolillo, et al., Nuovo Cimento **38**, 684 (1965).

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