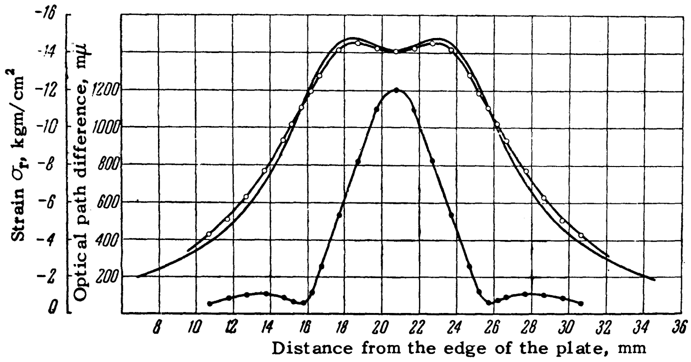

FIG. 3. Distribution of the strain σ_r for the load P = 5.784 kgm at the cross section h = 5 mm; continuous line – theoretical curve, o – experimental results, • – optical path difference.

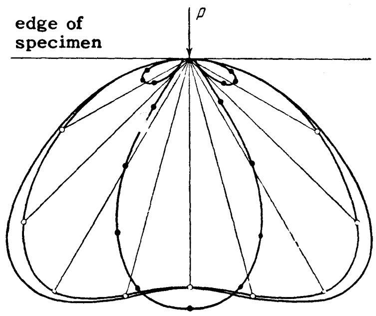

FIG. 4. Curves σ_r = const: continuous line – theoretical curve for σ_r = 16.3 kgm/cm² = const; o – experimental values for σ_r = 16.3 kgm/cm² = const; • – isochrome of the first order; P = 5.784 kgm.

curve, there is drawn one of the isochromes which shows clearly that the anisotropy of the photoelastic properties is sharply distinguished from the anisotropy of the elastic properties. In the case of an isotopic body, these curves coincide, as is well known. One must turn one's attention also to the fact that the maximum value of the radial strain σ_2 takes place not on the line of action of the force, but on the two rays located symmetrically relative to this line.

In conclusion, we consider it our pleasant task to thank A. L. Shakh-Budagov for his assistance in carrying out this research.

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STRANGE-PARTICLE DECAYS IN THE THEORY OF FEYNMAN AND GELL-MANN

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An explanation is given for the equal probabilities of the K_{e3} and $K_{\mu 3}$ decays in the absence of K_{e2} decay, and of the large asymmetry in the decays of polarized hyperons. The assumption used is that of a universal A — V interaction as proposed by Feynman and Gell-Mann.

ONE of the most interesting facts relating to the lepton decays of K mesons is the absence of the decay $K^+ \rightarrow e^+ + \nu$ and the presence of the decay $K^+ \rightarrow \mu^+ + \nu$, together with the approximately equal probabilities of the decays $K^+ \rightarrow \mu^+ + \nu + \pi^0$ and $K^+ \rightarrow e^+ + \nu + \pi^0$.

We would like to point out that these facts can be explained in an altogether natural way if one assumes that all of these decays occur on account of the universal four-fermion interaction proposed by Gell-Mann and Feynman[1] and by Sudarshan and Marshak.[2] If one assumes that such an interaction exists, then the decays $K^+ \to \mu^+ + \nu$ and $K^+ \to e^+ + \nu$ must occur through the conversion of the K meson into a baryon-antibaryon pair and the subsequent conversion of the latter into $e\nu$ or $\mu\nu$, which goes through the weak four-fermion interaction

$$(G/\sqrt{2})\,(\bar{\psi}_Y\gamma_\mu(1+\gamma_5)\,\psi_N)\,(\bar{\psi}_\nu\gamma_\mu(1+\gamma_5)\,\psi_e).$$

In its general form, the diagram for such a process can be drawn as in Fig. 1a. Just as in the case

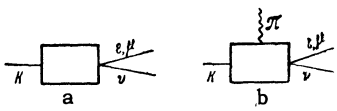

FIG. 1

of the analogous decays of the π meson,[1] the corresponding matrix element has the form

$$F \sim fMG\,(\bar{\psi}_\nu\hat{p}_K(1+\gamma_5)\,\psi_{\mu,e}),$$

where M is the mass of the nucleon and f is a numerical constant which is the same for the μ meson and the electron (in view of the fact that the matrix element for the transition can depend only on p_K).

The corresponding probability w is proportional to $1 + (v_{\mu,e}/c)\cos\vartheta$ where ϑ is the angle between the directions of the momenta of the μ meson (or electron) and the neutrino. For the two-particle decay $\cos\vartheta = -1$, so that the probability is proportional to $1 - v/c$ and is extremely small for the electron case. The ratio of the probabilities of the decays $K \to e + \nu$ and $K \to \mu + \nu$ is given by

$$\frac{K \to e+\nu}{K \to \mu+\nu} \approx \left(\frac{m_e}{m_\mu}\right)^2 \sim 0.25\cdot 10^{-4}.$$

The situation is decidedly different when a π meson comes off from the baryon loop. The corresponding diagram has the form shown in Fig. 1b. The general form of the corresponding matrix element is

$$F \sim f_1G\,(\bar{\psi}_\nu\hat{p}_K(1+\gamma_5)\,\psi_{e,\mu}) + f_2G\,(\bar{\psi}_\nu\hat{p}_\pi(1+\gamma_5)\,\psi_{\mu,e}). \quad (2)$$

Noting that $p_K = p_{e,\mu} + p_\nu + p_\pi$ and using the Dirac equation, we can put Eq. (2) in the form

$$F \sim (f_1+f_2)\,G\,(\bar{\psi}_\nu\hat{p}_K(1+\gamma_5)\,\psi_{e,\mu}) + f_2m_{e,\mu}G\,(\bar{\psi}_\nu(1-\gamma_5)\,\psi_{e,\mu}). \quad (3)$$

If we consider the simplest diagrams of the form 1b (see Fig. 2), we find that they lead to logarith-

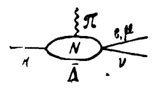

FIG. 2

mically divergent integrals. If we keep only the logarithmic term, then $f_1 = f_2$, independently of the parity of the K meson.

We shall assume that $f_1 \approx f_2$; then we can neglect the second term in Eq. (3) (which gives for the μ meson an error of the order of 10 percent) and write Eq. (3) in the same form as Eq. (2):

$$F \sim f\,(\bar{\psi}_\nu p_K(1+\gamma_5)\,\psi_{\mu,e}). \quad (4)$$

The probabilities of the decays K_{e3} and $K_{\mu3}$ are proportional as before to $1 + (v/c)\cos\vartheta$, but since these are three-particle decays, $\cos\theta$ no longer has to be equal to -1. For this reason the forbidden character found for the decay $K \to e + \nu$ is not found for the decay $K \to e + \nu + \pi$, and we get for the ratio of the probabilities

$$\frac{K \to e+\nu+\pi}{K \to \mu+\nu+\pi} \sim 1.$$

This result always holds as to order of magnitude, provided only that $f_1 \neq -f_2$; that precise equality should occur appears improbable. We note that the spectrum of the μ mesons and electrons for the interaction (4) and for other possible types of interaction has been examined by Furiuchi and others;[3] the angular correlations between the momenta of the π meson and electron (which are easily observable in the case of the decay $K^0 \to e^\pm + \nu + \pi^\mp$, which is the analogue of the corresponding K^+ decay) have been obtained by Pais and Treiman.[4]

It must be remarked that the application of analogous considerations to the decays $\pi \to e + \nu$, $\pi \to \mu + \nu$ gives for the ratio of the decay probabilities

$$\frac{\pi \to e+\nu}{\pi \to \mu+\nu} \approx 1.3\cdot 10^{-4}$$

(see, for example, Ref. 1). The decay $\pi \to e + \nu$ has not been observed. Lattes and Anderson[5] give an upper limit 10^{-5} for this ratio. We believe, however, that the question of the esistence of the decay $\pi \to e + \nu$ calls for further examination.

The question arises as to whether the forbiddenness of the decay $\pi \to e + \nu$ can be removed on account of the emission of a γ-ray quantum in the decay $\pi \to e + \nu + \gamma$, which would give

$$\rho_\gamma = \frac{\pi \to e+\nu+\gamma}{\pi \to \mu+\nu} \sim e^2\,\frac{K \to e+\nu+\pi}{K \to \mu+\nu} \sim 10^{-3},$$

This would be in contradiction with the experiments of Cassels,[6] which gave for ρ_γ the upper limit ρ_γ

$< 10^{-5}$. Actually it can be shown that both the A and V types of interaction give $\rho_\gamma \sim 10^{-7}$. For the A interaction this has been shown in a paper by Treiman and Wyld[7] (cf. also Ref. 8); the corresponding calculations for the V interaction have been carried out by V. G. Vaks (private communication).

The existence of the universal A — V interaction also explains in a natural way the large asymmetry in the hyperon decays $Y \rightarrow N + \pi$. If we describe such decays by the simplest diagrams of perturbation theory (Fig. 3), we get for the matrix element

$$F \sim fGM\,(\bar{\psi}_N \hat{k}\,(1+\gamma_5)\,\psi_Y),$$

where k is the momentum of the π meson.

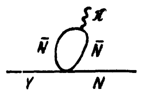

FIG. 3

In the approximation in which the nucleon is nonrelativistic we get

$$F \sim fGM\,(\psi_N^{*}\,(k_0 + \sigma\mathbf{k})\,\psi_Y).$$

If the decaying hyperon is completely polarized, the probability of emergence of the nucleon at an angle ϑ with the direction of the hyperon spin is proportional to the quantity $1 + \alpha \cos\vartheta$, where

$$\alpha = 2\,(k/k_0)\,/\,[1 + (k/k_0)^2],$$

which for the decay of a polarized Λ hyperon gives $\alpha \sim 0.9$. The latest experimental data on the decay of Λ particles formed in the reaction $\bar{\pi} + p \rightarrow \Lambda + K$ lead to the following effective value of the constant α: $\alpha_{\text{eff}} = 0.77 \pm 0.16$. From this it must be concluded that the Λ particle produced in this reaction is polarized in the plane of its production, with the average polarization lying in the range between ⅔ and 1.

The considerably smaller value of the asymmetry in the decay of Σ particles produced in the same reaction $\bar{\pi} + p$ must evidently be ascribed to the fact that the polarization of these hyperons at the time of their production is considerably less than that of Λ particles.

We note that according to the scheme considered here, the ratio of the probabilities for the decays $\Lambda \rightarrow p + \pi^-$ and $\Lambda \rightarrow n + \pi^0$ is mainly determined by the relative probability for production of a charged or a neutral π meson by a baryon, i.e., is about equal to 2, which is close to the experimental value.

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