[3] T. D. Lee and C. N. Yang, Phys. Rev. 102, 290; 104, 822 (1956).
[4] A. Salam, Nuclear Phys. 2, 173 (1956).

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INTERACTION OF FERMIONS AND THE $K_{\mu 3}$-DECAY

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THE weak interaction of four fermions plays, apparently, an important role in the decays of K-mesons into leptons ($K_{\mu 2}$, $K_{\mu 3}$, K_{e3}). An important problem is the clarification of the variants of this interaction in K_{e3}- and $K_{\mu 3}$-decays. With this in mind, the energy spectrum of the electrons and μ-mesons[1–3] and the angular correlation between the π-meson and electron (μ-meson)[4] were studied.

In the usual investigation of the energy spectrum of μ-mesons[1–3] (electrons) it is necessary, as a result of lack of information about strong interactions, to make definite assumptions about the dependence of these interactions on the particle momenta (it is easy to see[4] that in this problem there is only one independent momentum, for example, p_π). However, Okun'[5] proposed to study the spectrum of electrons from K_{e3}-decay, fixing the energy of the π-mesons. In this investigation definite conclusions can be drawn about the presence of this or that variant and about the conservation of parity with respect to reflection in time in the K_{e3}-decay process, independently of knowledge of strong interactions.

In this note we consider the analogous case of $K_{\mu 3}$-decay. Although here, as compared to K_{e3}, the analysis is made more difficult because it is impossible to neglect the mass of the μ-meson, some conclusions can be drawn all the same. This is of some interest also in connection with the long-standing question as to whether the μ-meson and electron are interchangeable in weak interactions of four fermions.

According to Pais and Treiman[4] the matrix element of $K_{\mu 3}$-decay of a K-meson at rest has, in the general case, the following form (without introduction of derivative lepton functions):

$$R = \left[\left(f_S - g_V \frac{m_\mu}{M}\right)\bar{\psi}_\mu \psi_\nu + f_V \bar{\psi}_\mu \gamma_4 \psi_\nu + \frac{f_T}{M}\bar{\psi}_\mu \gamma_4 \gamma P_\pi \psi_\nu\right](2M^{3/2}E_\pi^{1/2})^{-1}. \tag{1}$$

Here $f_{S,V,T}$ and g_V are dimensionless scalar functions of the π-meson energy, expressing the contributions of strong interactions in intermediate states (at the present time they are unknown); M is the mass of the K-meson, $P_\pi = \sqrt{E_\pi^2 - m_\pi^2}$; $\hbar = c = 1$ everywhere.

Calculation of the probability of emission of a μ-meson with energy E_μ and a π-meson of energy E_π gives

$$\begin{aligned} w(E_\pi, \varepsilon) = \frac{(M-E_\pi)^3}{32\pi^3 M^3}\Big\{ & |f_{S'}|^2(1-\varepsilon_0^2+\mu_0^2) + |f_V|^2(\varkappa^2-(1-\varepsilon)^2) + |f_T|^2\left(1-\frac{E_\pi}{M}\right)^2[\mu_0^2(\varkappa^2+2(1-\varepsilon)) \\ & + (1-\varepsilon_0^2)(1-\varepsilon)^2] + 4\,\mathrm{Re}(f_S f_V^+)\mu_0(1-\varepsilon) + 2\,\mathrm{Im}(f_S f_T^+)\left(1-\frac{E_\pi}{M}\right)[\mu_0^2+(1-\varepsilon_0^2)(1-\varepsilon)] \\ & + 2\,\mathrm{Im}(f_V f_T^+)\mu_0\left(1-\frac{E_\pi}{M}\right)(1+\varkappa^2-\varepsilon)\Big\}; \quad \varepsilon_0 = P_\pi/(M-E_\pi); \quad \varepsilon = 2E_\mu/(M-E_\pi); \\ & f_{S'} = f_S - g_V\frac{m_\mu}{M}; \quad \varkappa^2 = \varepsilon_0^2+\mu_0^2; \quad \mu_0 = m_\mu/(M-E_\pi); \quad 0 \leqslant \varepsilon_0/\mu_0 \leqslant 2. \end{aligned} \tag{2}$$

Following Okun', we consider the spectrum of μ-mesons for a fixed energy of the π-meson. Then we will have

$$w(\varepsilon) = \Phi_{S'} + \Phi_V(\varkappa^2 - (1-\varepsilon)^2) + \Phi_T[\mu_0^2(\varkappa^2 + 2(1-\varepsilon)) + (1-\varepsilon_0^2)(1-\varepsilon)^2] + \Phi_{SV}\mu_0(1-\varepsilon) + \Phi_{ST}[\mu_0^2 + (1-\varepsilon_0^2)(1-\varepsilon)] + \Phi_{VT}\mu_0(1+\varkappa^2-\varepsilon), \quad (3)$$

where the coefficients Φ do not depend on E_μ; the first three are positive. With conservation of temporal (combined) parity we have $\Phi_{ST} = \Phi_{VT} = 0$. In this case it is possible, in general, to have interference between S- and V-variants ($\Phi_{S'}$ and Φ_{SV}). In contradistinction to the K_{e3} case, it is impossible here to say that the presence of symmetry relative to the point $\epsilon = 1$ means that the interfering terms are zero (in the T-variant we have the term with $1 - \epsilon$).

Integrating over ϵ, which can be done without any assumptions about strong interactions, does not give anything so clear as in the K_{e3} case, and we will not give the result here.

We note that, as in the K_{e3} case, the $K_{\mu 3}$ spectrum of π-mesons can, in principle, give information for determining the form of the functions Φ.

I should like to use this opportunity to express my gratitude to L. B. Okun' for sending the manuscript of his work before publication.

[1] S. Furuichi et al., Progr. Theoret. Phys. **16**, 64 (1956); **17**, 89 (1957).
[2] S. G. Matinian, J. Exptl. Theoret. Phys. (U.S.S.R.) **31**, 529 (1956), Soviet Phys. JETP **4**, 434 (1957).
[3] S. G. Matinian, J. Exptl. Theoret. Phys. (U.S.S.R.) **32**, 929 (1957), Soviet Phys. JETP **5**, 757 (1957).
[4] A. Pais and S. B. Treiman, Phys. Rev. **105**, 1616 (1957).
[5] L. B. Okun', J. Exptl. Theoret. Phys. (U.S.S.R.) (in press), Soviet Phys. JETP (in press).

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MEASUREMENTS OF MOLECULAR ATTRACTION BETWEEN DISSIMILAR SOLIDS

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THE present report is a continuation of the article[1] in which the basic theory of this problem was given, the method of measurement was described in detail, and the results of measurement of molecular attraction between fused quartz plates and lenses was given.

We chose fused quartz as basic material for preparation of specimens in the first experiments for the following reasons: its transparency allows the use of the most accurate optical method for determining the size of the gap between the surfaces; its surfaces can easily be given a high polish; and, lastly, quartz surfaces are not damaged by the various cleaning methods. All the above qualities of quartz surfaces make it possible to obtain and measure small gaps between the surfaces.

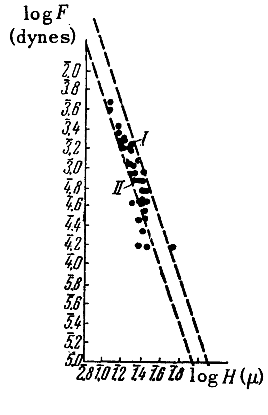

FIG. 1

The smallness of the forces of attraction between macroscopic objects makes it desirable to choose materials which, other things being equal, are characterized by large interaction forces. According to the theory of E. M. Lifshitz[2,3] the magnitude of the interaction force depends only on the electrostatic value of the dielectric constant ϵ_0 for sufficiently large distances between the bodies. The energy of attraction U, per cm², of two parallel plates may be written in the form

$$U = -\frac{K}{H^3}, \quad K = \frac{\hbar c}{3}\frac{\pi^2}{240}\left(\frac{\varepsilon_0 - 1}{\varepsilon_0 + 1}\right)^2 \varphi(\varepsilon_0) \quad (1)$$

(H is the magnitude of the gap between the surfaces, $\hbar$ is Planck's constant, c is the velocity of light, and $\varphi(\epsilon_0)$ is a function tabulated in Ref. 2). For the majority