This proposal is published because "meson factories" are soon to be constructed, and the planning of shields for experiments with beams of neutrinos from stopped mesons should already be undertaken now. We note in conclusion that, regardless of the search for the multiplicative quantum number, the analysis of the neutral products of muon decay is of independent interest.

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CONCERNING (V + A) CURRENTS IN WEAK INTERACTIONS OF ELEMENTARY PARTICLES

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Submitted 15 December 1967
ZhETF Pis'ma 7, No. 4, 139-142 (20 February 1968)

The model proposed by one of the authors [1,2] for weak interactions of elementary particles with one lepton charge and broken (V ± A) symmetry (with domination of (V - A)) leads to a large number of consequences that can be used for experimental searches of (V + A) currents and to establish the upper limit of the admixture of (V + A) coupling in the current-current weak-interaction Lagrangian. A method was described in [2] for constructing effective Lagrangians of different weak processes in which leptons participate in the presence of (V + A) coupling, and several effects were considered in known weak processes such as μ, π, and β decays and experiments with high-energy neutrinos. In this paper we consider the effect of (V + A) currents in the exact form of the spectrum and angular correlations of μ-decay electrons in the entire range of momentum variation, from $p = 0$ to $p = p_{max}$. The discussion of this effect, in which interference takes place between the (V - A) and (V + A) couplings, has become more timely in connection with recently undertaken measurements of the μ-decay electron spectrum at decreasing energies [3].

Using the expression for the μ-decay Lagrangian from [2]

$$L_\mu = \frac{g}{\sqrt{2}}(\bar{\nu}_\mu \gamma_a (1+\gamma_5)\mu)(\bar{e}\gamma_a(1+\gamma_5)\nu_e) - \sqrt{2}g_1(\bar{\nu}_\mu(1-\gamma_5)\mu(\bar{e}(1+\gamma_5)\nu_e), \tag{1}$$

we get with the aid of the standard projection-operator technique [4] for the differential probability of the decay of a polarized muon at rest decaying on an electron with energy $\epsilon = E/E_{max}$ and momentum $x = p/p_{max}$

$$\frac{4\pi}{d\Omega}\frac{dw}{d\epsilon} = \frac{m_\mu^5 G^2}{192\pi^3} x\epsilon\{D_0 + D_1(\vec{\sigma}_\mu n) + D_2(\vec{\sigma}_e n) + \tag{2}$$

$$+ D_3(\vec{\sigma}_\mu n)(\vec{\sigma}_e n) + D_4[(\vec{\sigma}_\mu \vec{\sigma}_e) - (\vec{\sigma}_\mu n)(\vec{\sigma}_e n)]\},$$

where the electron spectrum $D_0(\epsilon)$ and other energy distributions $D_i(\epsilon)$ are of the form

$$D_0(\epsilon) = 3 - 2\epsilon + 12\lambda\eta \frac{1 - \epsilon}{\epsilon}, \tag{3}$$

$$D_1(\epsilon) = (1 - 2\eta^2)(1 - 2\epsilon)x/\epsilon, \tag{4}$$

$$D_2(\epsilon) = -(1 - 2\eta^2)(3 - 2\epsilon)x/\epsilon, \tag{5}$$

$$D_3(\epsilon) = -(1 - 2\epsilon + 4\lambda\eta \frac{1 - \epsilon}{\epsilon}), \tag{6}$$

$$D_4(\epsilon) = -2(\eta + \lambda \frac{1 - \epsilon}{\epsilon}), \tag{7}$$

$$\eta = -\mathcal{G}\mathcal{G}_1 / G^2, \; \lambda = m_e / m_\mu, \; G = (\mathcal{G}^2 + \mathcal{G}_1^2)^{1/2}. \tag{8}$$

Here $\vec{\sigma}_e$ and $\vec{\sigma}_\mu$ are unit vectors of the electron and muon polarization in their rest frames, and $\vec{n}$ is a unit vector in the direction of the electron momentum.* In (3) the Michel parameter is $\rho = 3/4$, and η is the second Michel parameter [4] for the form of the spectrum at low energies. $\eta = 0$ in the case of pure (V - A) coupling. The appearance of the first power $\eta \neq 0$ in the formulas (3), (6), and (7) is in our case the effect of the interference between the (V - A) and (V + A) couplings. Since the same parameter η appears in the electron spectrum $D_0(\epsilon)$ and in the energy dependence of the angular distributions $D_i(\epsilon)$, it can be determined experimentally both by accurate measurement of the spectrum and by accurate measurement of the asymmetry and of the longitudinal or transverse electron polarization. Formulas (2) - (7) describe the spectrum and the energy distributions for the angular correlations of the electrons in μ decay in the entire interval of possible momenta $0 \leq x \leq 1$, accurate to terms proportional to m_e/m inclusive, but without allowance for radiative losses. In comparing these formulas with experiment, account must be taken of the results of the calculations of the radiative corrections [7], as was done, for example, in [3]. The corrections to the final expressions from the terms $\sim\lambda^2$ are negligible, smaller than 1% in the entire region of the spectrum $0 \leq x \leq 1$. Formulas (2) - (7) are for μ^--meson decay. In the case of μ^+-meson decay it is necessary to reverse the signs of the asymmetry and of the longitudinal polarization. The true Fermi constant, which is determined from the experimental value of the muon lifetime, is in this case

$$G = (\mathcal{G}^2 + \mathcal{G}_1^2)^{1/2} = 1{,}01 \pm 0{,}01 (10^{-5}/M_p^2)$$

The results of the exact measurements of the asymmetry of the positrons from μ^+ decay [8] make it possible to establish the upper limit $|\eta| \lesssim 0.1$.

The following remark is significant: If the semiweak interaction with intermediate W bosons is indeed the primary one, then

$$\mathcal{G}/\sqrt{2} = 4\pi g^2/M_1^2, \quad \mathcal{G}_1/\sqrt{2} = 4\pi g^2/M_2^2, \quad \eta < 0. \tag{9}$$

Consequently, an experimental determination of the sign of the parameter η would be important, for a positive sign excludes the W-boson hypothesis within the framework of the model of [2].

It is important to note that an experimental observation that $\eta \neq 0$ would by itself still not denote that (V + A) currents exist, for it can be seen from (1) that $\eta \neq 0$ could also be the consequence of the presence of scalar (but not tensor) currents. However, a detailed analysis shows that if the μ decay should reveal the presence of not only $\eta \neq 0$ but also the reaction $\nu_\mu + p \to n + e^+$ in experiments with high-energy neutrinos, this could already suffice (within the framework of the assumptions of [2]) for an unequivocal conclusion of the existence of (V + A) currents and a (V + A)(V + A) coupling in weak interactions of elementary particles.

The ratio of the cross sections of reactions (11) and (10),

$$\pi^+,\ K^+ \to \mu^+ + \nu \begin{cases} \longrightarrow \nu + n \to p + \mu^-, & (10) \\ \longrightarrow \nu + p \to n + e^+, & (11) \end{cases}$$

is uniquely related to the spectrum form parameter η by

$$\sigma(\nu + p \to n + e^+)/\sigma(\nu + n \to p + \mu^-) = 2\eta^2 . \tag{12}$$

A similar relation holds for reactions with neutrinos from π^-- and K^--meson decay. The existence of the correlations (12) is the most interesting consequence of the model of [2] and may stimulate experimental research.

It is easy to verify that in view of the "neutrino-jump" phenomenon that takes place in (V + A) currents [2] ($\nu_e \rightleftharpoons \bar{\nu}_\mu$, $\nu_\mu \rightleftharpoons \bar{\nu}_e$), the list of weak processes with lepton participation, in which interference of the (V - A) and (V + A) couplings can take place in first order in G^2, is limited to effects that are described by the μ-decay Lagrangian (1). However, a discussion of small interference corrections to the cross sections of the reactions $\nu + e \to \mu + \nu$, $\nu + Z \to Z + \mu + e + \nu$, etc. is premature.

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* Formulas (2) - (7) can also be derived from the published general expressions of the μ-decay spectrum for the case of a two-component neutrino, say from Shekhter's paper [5].