[1] D. Pines and P. Nozieres, Theory of Quantum Liquids, Benjamin, 1966.
[2] Sh. M. Kogan and R. A. Suris, Zh. Eksp. Teor. Fiz. 50, 1279 (1966) [Sov. Phys.-JETP 23, 850 (1966)].
[3] I. M. Lifshitz, ibid. 17, 1017 and 1076 (1947).
[4] P. Anderson, Phys. Rev. 124, 41 (1961).
[5] R. London, Adv. in Phys. 17, 243 (1968).

POSSIBLE SEARCH FOR $K^+ \to \pi^+ + \nu + \nu$ DECAYS

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In the customary theory [1] it is assumed that the Lagrangian of the weak interaction contains the product of only charge currents. This limitation is connected with the fact that experiments have not revealed decays of strange particles of the type

$$K^0 \to \mu^+ + \mu^-, \tag{1}$$

$$K^+ \to \pi^+ + e^+ + e^-, \text{ etc.} \tag{1b}$$

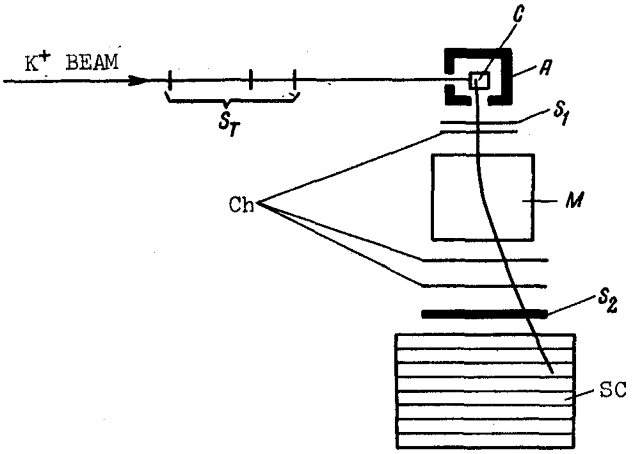
The decays (1), however, are possible in second order weak-interaction perturbation theory. The application of current-algebra methods to them has led to an unexpected conclusion (see [2]) that the weak interactions conserve the current-current form only up to relatively small momentum values.

This result may signify that the weak interaction has a much more complicated structure and is represented in the form of the product of currents only in the low-energy limit. Examples of such more complicated schemes of weak interaction are two models of the renormalizable interaction, proposed respectively by Tanikawa-Wanatabe [3] and Kummer-Segre [4]. Investigations have shown (see [5,6]) that these models agree with modern data, and whereas in the former model (T-W) the agreement between the vector constants of the neutron and muon decay is accidental, in the second model the equality of these constants is predicted by the theory [6].

An interesting feature of the renormalizable models is that transitions with change of strangeness and with emission of two leptons, i.e., of type (1), are forbidden in them (in the lowest order of perturbation theory), but transitions with emission of a neutron pair, i.e., of the type

$$K^+ \to \pi^+ + \nu + \bar{\nu} \tag{2}$$

are allowed, although they may be somewhat suppressed. We note that in the case of the second model, according to [6], the possibility of an appreciable suppression of emission of $\nu\bar{\nu}$ compared with emission of the $\ell^\pm\nu$ pair is not excluded.



The experimental limitations on the probability of the process (2) are quite insignificant. In the literature there are two figures:

$$\frac{w(K^+ \to \pi^+ + \nu_e + \bar{\nu}_e)}{w(K^+ \to \pi^0 + e^+ + \nu_e)} \leqslant \begin{cases} 1/3, & [7] \\ 1/17, & [5] \end{cases}$$

whereas the limitations on the processes (1) are lower by several orders of magnitude.

There are two main causes for searching for decays of the type (2).

1. If it is demonstrated that the limits on the processes (2) and (1b) coincide, this would be evidence in favor of the theory of the type considered in [8], although it would not exclude the second model, which admits of strong suppression of neutrino currents.

2. If the process (2) is observed with the probability larger than the probability of the process (1b), then we obtain a confirmation of the renormalizability of weak-interaction theory. In the latter case we would have a theory having no difficulties in the high-energy limit.

In this paper we wish to call attention to the possibility of searching for the decays (2) up to a probability value

$$\frac{w(K^+ \to \pi^+ + \nu + \bar{\nu})}{w(K^+ \to \text{all})} \sim 10^{-5}.$$

Let us consider the following approximate experimental setup: a beam of K^+ mesons with momentum 250 MeV/c is stopped in a block of matter C (carbon, ≈ 5 g/cm^2). Around the block C, as shown in the figure, is located an anticoincidence counter A (sandwich, ~6 rad. un.), which excludes all events accompanied by charged particles or γ quanta entering in A. The particles from the block C can bypass the counter A only by falling in the magnet M and in the multilayer spark chamber SC located behind it (thickness ~6 rad. un.). The chambers Ch are used to measure the coordinates of the charged particle passing through the magnet. Thus, we measure the momentum of the particle and its range in the chamber SC. Assuming the transmission of the apparatus to be 0.01, corresponding to reasonable dimensions of the magnet and of the spark chambers, we find that ~100 stoppings of K mesons per accelerator pulse are necessary, and that the triggering will be produced essentially by $K_{\mu 2}$ decays.

At the thicknesses indicated above for the counter A and for the spark chambers, the level of the background from the decays of $K_{\pi 2}$, $K_{\pi 3}$, $K_{\mu 3}$, and K_{e3} accompanied by π^0 mesons amounts to $< 10^{-6}$ of the total number of the $K_{\mu 2}$ events. If the momentum measurement accuracy is ~3 - 5%, then the background due to the $K_{\mu 2}$ will be smaller than 10^{-6}. Consequently, the appearance of the background can be expected at probability levels 10^{-5} - 10^{-6} of the sought process. To obtain a probability level 10^{-5}, the accelerator would have to operate 100 - 200 hours.

[1] R. P. Feynman and M. Gell-Mann, Phys. Rev. 109, 193 (1958).
[2] B. L. Ioffe and E. P. Shabalin, Yad. Fiz. 6, 828 (1967) [Sov. J. Nucl. Phys. 6, 603

(1968)]; ZhETF Pis. Red. 6, 978 (1967) [JETP Lett. 6, 390 (1967)].

[3] Y. Tanikawa and S. Watanabe, Phys. Rev. 113, 1344 (1959).

[4] W. Kummer and G. Segre, Nucl. Phys. 64, 585 (1965).

[5] E. P. Shabalin, Yad. Fiz. 8, 74 (1968) [Sov. J. Nucl. Phys. 8 (1969)].

[6] E. P. Shabalin, ibid. [sic!].

[7] L. B. Okun', Voprosy fiziki elementarnykh chastits (Problems of Elementary Particle Physics), Vol. 4, 1964, p. 295.

[8] M. Gell-Mann, M. L. Goldberger, N. M. Kroll, and F. E. Low, Preprint.