THE POSSIBILITY OF CHECKING THE $\Delta T = 1/2$ RULE IN REACTIONS OF SINGLE PRODUCTION OF STRANGE PARTICLES

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The $\Delta T = 1/2$ rule for nonleptonic weak processes was proposed in [1] on the basis of phenomenological considerations, and agrees well with experiment [2-4]. After the appearance of the V - A theory [5,6], its existence has turned into a problem, since both $\Delta T = 1/2$ and $\Delta T = 3/2$ transitions arise in the usually considered form of this theory [7] $L_w = J_i J_l^+$, where J_i is the charged current. Attempts to obtain a dynamic explanation of the $\Delta T = 1/2$ rule within the framework of the $J_i J_l^+$ scheme, or to obtain a relation replacing it [8-12], were not successful, and estimates of its importance fluctuate greatly [13,14]. A conviction was expressed in [4] that "this problem will stay with us for a long time."

In [15] it was proposed to check the $\Delta T = 1/2$ rule in reactions of single production of strange particles at high energies and momentum transfers. If the $\Delta T = 1/2$ rule is satisfied under these conditions, then apparently it can be concluded with a high degree of likelihood that it is exact for weak interaction and that the $J_i J_l^+$ hypothesis is incorrect. However, the reactions proposed in [15] are not convenient experimentally. We wish to call attention in this note that reactions with single production of strange particles and formation of the isobar Δ (1246 MeV) and (or) isoscalar mesons may turn out to be more convenient. We present below relations, resulting from the $\Delta T = 1/2$ rule, between the cross sections of this type of reactions.

$$\begin{aligned} &p + p \to \Delta^{++} + \Lambda \quad 3\sigma_1; \\ &p + n \to \Delta^{+} + \Lambda \quad \sigma_1; \end{aligned} \qquad (1)$$

$$\begin{aligned} &K^+ + p \to \Delta^{++} + \eta \quad 3\sigma_2 \qquad K^\circ + p \to \Delta^{+} + \eta \quad \sigma_2; \\ &K^+ + n \to \Delta^{+} + \eta \quad \sigma_2 \qquad K^\circ + n \to \Delta^{\circ} + \eta \quad \sigma_2; \end{aligned} \qquad (2)$$

$$\begin{aligned} &K^+ + d \to \Delta^{++} + n \quad 3\sigma_3 \qquad K^+ + d \to \Delta^{+} + p \quad \sigma_3; \\ &K^\circ + d \to \Delta^{+} + n \quad \sigma_3 \qquad K^\circ + d \to \Delta^{\circ} + p \quad \sigma_3; \end{aligned} \qquad (3)$$

$$\begin{aligned} &K^+ + d \to d + \pi^+ \quad 2\sigma_4; \\ &K^\circ + d \to d + \pi^\circ \quad \sigma_4; \end{aligned} \qquad (4)$$

$$\begin{aligned} &\pi^+ + d \to \Delta^{++} + \Lambda \quad 3\sigma_5; \\ &\pi^- + d \to \Delta^{\circ} + \Lambda \quad \sigma_5. \end{aligned} \qquad (5)$$

The corresponding cross section is indicated alongside each reaction.

Let us make a few remarks concerning the proposed reactions.

An investigation of the second reaction in (1) either requires a neutron beam or should be carried out on deuterons. In the latter case, however, difficulties connected with the presence of the third particle may arise when attempts are made to separate this reaction;

the same holds for (2). Relations similar to (2) - (4) can be obtained also for K^0 and K^- mesons.

We note that in checking relations in which K^0 mesons take part we must have precisely K^0 mesons, obtained for example from the charge exchange $K^+ \to K^0$, and not K_2^0 mesons, since the $\Delta S = 1$ and $\Delta S = -1$ reactions cannot be separated for K_2^0.

The following relations hold for a beam of K_2^0 mesons:

$$\begin{gathered}\sigma(K_2^\circ p \to \Delta^+\eta) = \sigma(K_2^\circ n \to \Delta^\circ\eta), \\ |\sqrt{3\sigma(K^-p \to \Delta^\circ\eta)} - \sqrt{\sigma(K^+p \to \Delta^{++}\eta)}| \leqslant \sqrt{6\sigma(K_2^\circ p \to \Delta^+\eta)} \leqslant \\ \leqslant \sqrt{3\sigma(K^-p \to \Delta^\circ\eta)} + \sqrt{\sigma(K^+p \to \Delta^{++}\eta)},\end{gathered} \tag{6}$$

$$\begin{gathered}\sigma(K_2^\circ d \to \Delta^+ n) = \sigma(K_2^\circ d \to \Delta^\circ p), \\ \sqrt{3\sigma(K^+d \to \Delta^+p)} - \sqrt{\sigma(K^-d \to \Delta^-p)} \leqslant \sqrt{6\sigma(K_2^\circ d \to \Delta^\circ p)} \leqslant \\ \leqslant \sqrt{3\sigma(K^+d \to \Delta^+p)} + \sqrt{\sigma(K^-d \to \Delta^-p)}\end{gathered} \tag{7}$$

$$\begin{gathered}|\sigma(K^+d \to d\pi^+) - \sigma(K^-d \to d\pi^-)| \leqslant 2\sigma(K_2^\circ d \to d\pi^\circ) \leqslant \\ \leqslant \sigma(K^+d \to d\pi^+) + \sigma(K^-d \to d\pi^-).\end{gathered} \tag{8}$$

In reactions (2) and (6) we can consider in lieu of η^0 any isoscalar meson, ω, φ, or f^0, but reactions (2) with η are more convenient, for no problems of background will occur here. Finally, it is possible to use in (4) He_4 (and in principle any isoscalar nucleus) in lieu of d.

The most accessible and the easiest to interpret uniquely are apparently the reactions (3) with K^+ (upper line) and (5).

Of course, the verification of these relations is not an easy matter, since single production of strange particles has so far not been observed at all.

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[1] M. Gell-Mann and A. Pais, Proc. Glasgow Conf., p. 342, 1954.
[2] G. H. Trilling, Proc. of the Intern. Conf. on Weak Interactions, Argonne, p. 115, 1965.
[3] N. P. Samios, ibid. p. 189.
[4] N. Cabibbo, Report on the 13th Intern. Conf. on High Energy Physics, Preprint.
[5] R. P. Feynman and M. Gell-Mann, Phys. Rev. 109, 193 (1958).
[6] R. E. Marshak and E. C. G. Sudarshan, Phys. Rev. 109, 1860 (1958).
[7] L. B. Okun', Slaboe vzaimodeistvie elementarnykh chastits (Weak Interaction of Elementary Particles), p. 21, 1963.
[8] I. Yu. Kobzarev and I. E. Tamm, JETP 34, 899 (1958), Soviet Phys. JETP 7, 622 (1958).
[9] M. Gell-Mann, 1958 Annual Intern. Conf. on High Energy Physics at CERN, pp. 260-261, Geneva, 1958.

[10] S. Okubo, R. E. Marshak, and E. C. G. Sudarshan, Phys. Rev. 113, 944 (1959).
[11] H. Sugawara, Phys. Rev. Lett. 15, 870 and 977 (E) (1965).
[12] M. Suzuki, Phys. Rev. Lett. 15, 986 (1965).
[13] R. P. Feynman, Symmetries in Elementary Particle Physics, edited by A. Zichichi, pp. 161 and 477, 1965.
[14] M. A. Markov, Neitrino (Neutrinos), p. 10, 1964.
[15] I. Yu. Kobzarev and L. B. Okun', YaF 1, 160 (1965), Soviet JNP 1, 111 (1965).

THEORY OF THE DOMAIN WALL IN METALS UNDER THE CONDITIONS OF THE DE HAAS - VAN ALPHEN EFFECT

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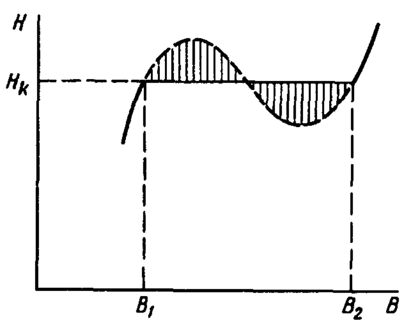
Under the conditions of the de Haas - van Alphen effect, several values of the induction B can exist on the "diagram of state" H(B) at a given value of the field H (see the figure).



The condition for the occurrence of the multiple values is the inequality $(\partial M/\partial B)_{max} > 1/4\pi$ [1]. The region of the curve between the points B_1 and B_2, determined by the equality of the shaded areas, corresponds to unstable states. It will be shown below that there can exist homogeneous phases with inductions B_1 and B_2, and that the surface tension on the interface is positive. Consequently a domain structure should appear in a sample with nonzero demagnetization factor [1].

The induction B varies in the transition region (domain wall) from a value B_1 to B_2, and therefore the connection between H and B is not the same as in the homogeneous case. The inhomogeneity must be taken into account, for if the connection between H and B were to remain constant, then the thickness of the transition layer and the surface tension would vanish. We consider essentially the case when the thickness of the transition layer is large compared with the cyclotron radius r_0, as is the case when the difference $B_2 - B_1$ is small compared with the period of the oscillations.

We calculate the magnetization increment due to the inhomogeneity in first approximation of perturbation theory, using the thermodynamic relation

$$M(x) = -\delta\Omega/\delta B(x); \quad \Omega = -T \ln Sp \exp(-H/T). \tag{1}$$

To this end, we put $B = B_0 + B'$, where B' is the inhomogeneous increment, and obtain Ω accurate to terms of second order in B'. We assume that B_0 and B' are parallel to the z axis, and that B' depends only on y.

The first-order correction to Ω is of no interest, since it does not contain the de-