the observed phenomenon. The fact that the amplitude of H_ω changes from zero up to the maximum along the specimen, which is a strip of resonant length, also speaks in favor of the absence of a dependence of the effect on H_ω.

The observed effect is anisotropic. Both the location and the amplitude of the oscillations are different in specimens with other crystallographic orientations, but the general character of the phenomenon is preserved: some oscillations of $\xi(H)$ are observed in the region $H < 5$ oe, changing to a monotonic variation upon increase in H. The oscillations have a much smaller amplitude in less pure specimens. The effect is completely absent in controlled experiments with specimens made from polycrystalline copper of technical purity.

The physical reasons for the new phenomenon just described are still not clear. There is a basis for assuming that the oscillations of the surface impedance take place as the result of quantum oscillations of the magnetic susceptibility of the metal. In particular, the connection of this phenomenon with the magnetic properties of a metal is shown by the character of its dependence on the direction of the constant magnetic field. It is possible that the phenomenon described is related to the de Haas—van Alphen effect. However, it differs qualitatively from the latter by highly characteristic features: the oscillations of ξ are nonperiodic as functions of H^{-1}, their periods are very small in absolute value and large in relative value. Strictly, the entire resemblance between these two effects is limited to the non-monotonic dependence of the magnetic susceptibility of the metal on the field.

It should be noted that the non-monotonic dependence of the surface impedance of the metal on the weak magnetic field is not only never observed experimentally, but also there do not exist theoretical calculations which would make it possible to predict or explain the nonlinear dependence of the surface impedance of the metal on the weak magnetic field, so strongly marked in the newly discovered phenomenon. The latter circumstance makes the further study of this phenomenon especially interesting.

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[1] M. Ya. Azbel' and É. A. Kaner, JETP **32**, 896 (1957), Soviet Phys. JETP **5**, 730 (1957).

[2] É. A. Kaner and M. Ya. Azbel', JETP **33**, 1461 (1957), Soviet Phys. JETP **6**, 1126 (1958).

[3] P. A. Bezuglyĭ and A. A. Galkin, JETP **34**, 237 (1958), Soviet Phys. JETP **7**, 164 (1958).

[4] M. S. Khaĭkin, JETP **37**, 1473 (1959), Soviet Phys. JETP **10**, 1044 (1960).

[5] V. B. Zernov and Yu. V. Sharvin, JETP **36**, 1038 (1959), Soviet Phys. JETP **9**, 737 (1959).

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PROPERTIES OF THE AXIAL VECTOR INTERACTION AND THE DECAY $\Sigma \to \Lambda + e + \nu$

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FEYNMAN, Gell-Mann, and Levy[1] have shown recently that, if one postulates

$$\partial_\alpha j_\alpha = Gfm^2\pi, \qquad (1)$$

for the divergence of the axial vector describing the strangeness conserving current j, the relation*

$$f = \sqrt{2}\, MG_A / gG \qquad (2)$$

follows without any further assumptions.

Here π is the operator of the π meson field, g is the coupling constant for the strong interaction of the π mesons with the nucleons ($g^2/4\pi \approx 14$), $G = 10^{-5}M^{-2}$ is the universal constant of the weak interaction, G_A is the axial vector coupling constant of β decay ($G_A \approx 1.25\,G$), and the lifetime of the π meson, τ, is given in terms of f in the following fashion (see, for example, the author's review article[2]):

$$1/\tau = (G^2/8\pi)\, f^2 m^2 \mu^2 (1 - \mu^2/m^2)^2, \qquad (3)$$

M, m, and μ are the mass of the nucleon, the π meson, and the μ meson, respectively. It follows from the comparison of formula (3) with experiment that $f \approx m$. This implies that relation (2) is satisfied with an accuracy of about 15%.

The condition (1), which was first considered by Polkinghorne,[4] requires very special assumptions about the form of both the strong and weak interactions.[1,4-6]† It is therefore desirable to derive other consequences, besides relation (2), from the hypothesis (1).

The aim of this letter is to show that the hypothesis (1) can be verified in an independent fashion by measuring the as yet unknown $\Sigma\Lambda\pi$ interaction constant and the probability of the as yet unobserved decay

$$\Sigma^{\pm} \rightarrow \Lambda^{0} + e^{\pm} \pm \nu. \qquad (4)$$

The axial vector part of the amplitude of the decay (4) has the form (see, for example, reference 2)

$$\langle \Lambda \mid j_{\alpha} \mid \Sigma \rangle = \bar{u}_{\Lambda} [A\gamma_{\alpha} + Bk_{\alpha} + C(\gamma_{\alpha}\hat{k} - \hat{k}\gamma_{\alpha})] Ou_{\Sigma}, \qquad (5)$$

where k is the summed four-momentum of the leptons, A, B, and C are functions of k^2, and the operator O is equal to γ_5 if the parities of Σ and Λ are identical ($P_{\Sigma\Lambda} = +1$), and equal to 1 if $P_{\Sigma\Lambda} = -1$. Using condition (1) we easily obtain

$$k_{\alpha} \langle \Lambda \mid j_{\alpha} \mid \Sigma \rangle = Gfm^2 \langle \Lambda \mid \pi \mid \Sigma \rangle = Gfm^2 \Gamma(k^2) D(k^2) \bar{u}_{\Lambda} Ou_{\Sigma}. \qquad (6)$$

Here the vertex part $\Gamma(k^2) = h\gamma(k^2)$, where h is the $\Sigma\Lambda\pi$ interaction constant, and $D(k^2) = (k^2 - m^2)^{-1}$ is the Green's function for the π meson, where $\gamma(m^2) = d(m^2) = 1$. Since the nearest singularities of $A(k^2)$, $\gamma(k^2)$, and $d(k^2)$ lie at $k^2 = 9m^2$, it may be expected that A, γ, and d change slowly in the interval $-m^2 \leq k^2 \leq m^2$.‡

Multiplying (5) by k_α and using (6), we find

$$Gfm^2\Gamma(k^2) D(k^2) = A(M_{\Sigma} \pm M_{\Lambda}) + Bk^2 \qquad (7)$$

(the upper sign corresponds to $P_{\Sigma\Lambda} = +1$, the lower sign to $P_{\Sigma\Lambda} = -1$). Considering equation (7) at the point $k^2 = m^2$, we obtain

$$B(k^2) \approx Gfh/(k^2 - m^2). \qquad (8)$$

If we look at (7) at the point $k^2 = 0$, we find

$$f \approx A(M_{\Sigma} \pm M_{\Lambda})/Gh. \qquad (9)$$

Relation (8) is not a specific consequence of the hypothesis (1); it should hold in any arbitrary theory if one assumes, as we essentially did, that the one-meson pole graph gives the most important contribution to $B(k^2)$ (the effective pseudoscalar) in the region $-m^2 \lesssim k^2 \lesssim m^2$.

Relation (9), which is the analog of (2), is a specific consequence of hypothesis (1). For its verification one must know the values of h and A.

By virtue of the conservation law for the vector current, the contribution of the vector interaction to the decay (4) is very small.[7,2,8] Therefore it is just the value of A (with an accuracy up to terms proportional to k in the amplitude) which determines the probability of the decay (4):

$$w_{\Sigma\Lambda} \approx 3A^2\Delta^5/60\pi^3, \quad \text{if} \quad P_{\Sigma\Lambda} = +1,$$
$$w_{\Sigma\Lambda} \approx A^2\Delta^5/60\pi^3 \quad \text{if} \quad P_{\Sigma\Lambda} = -1, \qquad (10)$$

where $\Delta = M_{\Sigma} - M_{\Lambda}$, and $\hbar = c = 1$ as in all the preceding equations. The value of the $\Sigma\Lambda\pi$ interaction constant h, on the other hand, might, for example, be obtained from an analysis of processes of the type

$$\Lambda(\Sigma) + N \rightarrow \Sigma(\Lambda) + N.$$

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*Relation (2) was first obtained by Goldberger and Treiman[3] with the help of dispersion theory techniques and a number of unjustified assumptions.

†We note that within the framework of the Sakata model relation (1) could serve as a definition of what is called the π meson field in the usual form of the weak interaction.

‡We note that the physical region of values of k^2 in the decay (4) lies within the limits $0 \leqslant k^2 \leqslant (M_{\Sigma} - M_{\Lambda})^2$.

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[1] Feynman, Gell-Mann, and Levy, preprint.

[2] L. Okun', Usp. Fiz. Nauk **68**, 449 (1959); Ann. Rev. Nucl. Sic. **9**, 61 (1959).

[3] M. Goldberger and S. Treiman, Phys. Rev. **111**, 354 (1958) and **110**, 1178 (1958).

[4] J. C. Polkinghorne, Nuovo cimento **8**, 179 and 781 (1958).

[5] R. E. Norton and W. K. R. Watson, Phys. Rev. **110**, 996 (1958).

[6] R. F. Swayer, Phys. Rev. **116**, 231 (1959).

[7] Belov, Mingalev, and Shekhter, JETP **38**, 541 (1960), Soviet Phys. JETP **11**, 392 (1960).

[8] N. Cabibo and R. Gatto, Nuovo cimento **15**, 159 (1960).

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THE PROBLEM OF THE FORM OF THE SPECTRUM OF ELEMENTARY EXCITATIONS OF LIQUID HELIUM II

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In a recently published preliminary communication by Henshaw, Woods, and Brockhouse,[1] data are given on the behavior of the energy spectrum of liquid helium II in the region of energies $\epsilon \approx 2\Delta$