

Assuming the correctness of the theory of weak interactions,^{4,5} we obtain the following equations for the correction constant C and for the polarization $\langle \sigma \rangle$:

$$C = \left(1 - \frac{2}{3} qy + \frac{1}{3} q^2 y^2\right) L_0 + 2 \left(y - \frac{1}{3} qy^2\right) N_0 + y^2 (M_0 + 2L_1),$$

$$\langle \sigma \rangle = -D/C, \quad (1)$$

whereupon D is obtained from C by substituting

$$L_0 \rightarrow L'_0 = (L_0^2 - P_0^2) \sin(\delta_{-1} - \delta_1),$$

$$M_0 \rightarrow M'_0 = (M_0^2 - Q_0^2) \sin(\delta_{-1} - \delta_1),$$

$$N_0 \rightarrow N'_0 = \frac{1}{2} [(L_0 + P_0)^{1/2} (M_0 + Q_0)^{1/2} + (L_0 - P_0)^{1/2} (M_0 - Q_0)^{1/2}] \sin(\delta_{-1} - \delta_1),$$

$$L_1 \rightarrow L'_1 = (L_1^2 - P_1^2)^{1/2} \sin(\delta_{-2} - \delta_2).$$

For determination of the functions L_0 , M_0 , N_0 , etc. see references 6 and 7; δ_1 , δ_{-1} , δ_2 , δ_{-2} are Coulomb phases; q is the neutron momentum. If we use the relation $Ze^2 \ll 1$, and the explicit expressions for the functions L_0 , M_0 , . . . ,^{6,8} we obtain the following simple equations for the β spectrum and for the longitudinal polarization of the β electrons in P^{32} :

$$C = 1 + a/\varepsilon, \quad \langle \sigma \rangle = -v(1 - a/\varepsilon), \quad (2)$$

where $a = \frac{2}{3} x [1 - (Ze^2/2\rho + \frac{2}{3} \varepsilon_0) x]^{-1}$, ε_0 is the spectral end-point energy. In deriving Eq. (2) we neglected terms in x^2 if they were multiplied by small quantities, i.e., a necessary condition for the validity of these equations is

$$x^2 \ll 1 - \left(Ze^2/2\rho + \frac{2}{3} \varepsilon_0\right) x.$$

Equations (1) and (2) convert into Morita's equation⁹ if we drop the quadratic terms in x^2 . For a value of $x = 0.08$ we obtain $a = 0.18$ which agrees with experimental data.¹⁻³ The deviation of the spectrum from a Fermi shape and of the polarization from v/c also occurs for In^{114} ($1^+ \rightarrow 0^+$ transition).^{2,3} The formally required value $a \sim 0.3$ is obtained for a value of $x = 0.057$. Although such a large value of x seems improbable because the quantity $\log ft$ equals 4.4 for In^{114} , it cannot be strictly ruled out.

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ON THE DECAY OF Σ HYPERONS

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THE experimental data on the probabilities and asymmetry coefficients of the decays of Σ hyperons by various channels evidently satisfy the rule $|\Delta I| = \frac{1}{2}$. If the $|\Delta I| = \frac{1}{2}$ rule receives final experimental confirmation, it will be necessary to renounce the theory of the universal weak interaction between charged currents.³ At present it is desirable to have more data to test this rule.

Let us denote the amplitudes for the processes $\Sigma^+ \rightarrow p + \pi^0$, $\Sigma^+ \rightarrow n + \pi^+$, and $\Sigma^- \rightarrow n + \pi^-$ by A_+ , A_0 , and A_- , respectively, where $A = a + ib(\sigma \mathbf{k})$; \mathbf{k} is the unit vector in the direction of motion of the nucleon. The absence of asymmetry in the decays $\Sigma^\pm \rightarrow n + \pi^\pm$ means that for these processes

$$\text{Re}(ab^*) = 0. \quad (1)$$

There are three ways to satisfy the condition (1):

1) $a = 0$, 2) $b = 0$, 3) the phases of a and b differ by 90° . Since the interaction of pion and nucleon in the final state is small, the third possibility violates the conservation of time parity.

Many authors^{2,3} have shown that the rule $|\Delta I| = \frac{1}{2}$ holds only for $a_0 = b_- = 0$ or $a_- = b_0 = 0$. To choose from among the three cases the one that exists in nature, one could use measurements of the polarization of the nucleons from the decay of polarized Σ^\pm particles produced in reactions $\pi^\pm + p \rightarrow \Sigma^\pm + K^+$.

Denoting the polarization vectors of nucleons and Σ hyperons by \mathbf{P} and \mathbf{P}_Σ , we get

$$\mathbf{P} = \frac{2\text{Re}(ab^*)}{|a|^2 + |b|^2} \mathbf{k} + \frac{|a|^2 - |b|^2}{|a|^2 + |b|^2} \mathbf{P}_\Sigma + \frac{2|b|^2}{|a|^2 + |b|^2} (\mathbf{P}_\Sigma \mathbf{k}) \mathbf{k} + \frac{2\text{Im}(ab^*)}{|a|^2 + |b|^2} [\mathbf{k} \times \mathbf{P}_\Sigma]. \quad (2)$$

In particular $\mathbf{P} = 2(\mathbf{P}_\Sigma \mathbf{k}) \mathbf{k} - \mathbf{P}_\Sigma$ for $a = 0$; $\mathbf{P}_\Sigma = \mathbf{P}$ for $b = 0$; and for the third case \mathbf{P} has a component along the direction of $\mathbf{k} \times \mathbf{P}_\Sigma$.

It is obvious that a measurement of the direction of the polarization vector of the nucleons will not only give information to test the rule $|\Delta I| = \frac{1}{2}$, but can also help to choose one solution from the two that are possible ($a_0 = b_- = 0$ or $a_- = b_0 = 0$) if this rule holds.

If there is no transverse polarization of the neutrons from Σ^- decay, this means that the initial Σ^- particle is unpolarized. In this case the absence of asymmetry in the Σ^- decay does not lead to Eq. (1). The quantity $\text{Re}(ab^*)$ can be determined from a measurement of the longitudinal polarization of the neutrons.

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ON THE PROCESS $e^- + p \rightarrow \Lambda + \nu$

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SO far only two decays $\Lambda \rightarrow p + e^- + \bar{\nu}$ have been found,¹ although according to the universal V-A interaction theory (without, however, taking into account the renormalization of the decay coupling constants) approximately 20 times as many events should have been seen. The rarity of hyperon leptonic decays makes the study of them very difficult. For this reason it becomes of interest to study the inverse process

$$e^- + p \rightarrow \Lambda + \nu, \quad (1)$$

which is due to the same interaction as the β decay of the Λ hyperon, but whose statistics may, in principle, be made rather large.

$$d\sigma = \frac{d(-Q^2)}{16\pi E^2 m_p^2} \{ (C_V^2 + C_A^2) [8m_p^2 E^2 - (4m_p E + Q^2)(m_\Lambda^2 - m_p^2 - Q^2)] - (C_A^2 - C_V^2) 2m_\Lambda m_p Q^2 - (B_A^2 - B_V^2) 2m_\Lambda m_p Q^4 + (B_V^2 + B_A^2) [-8m_p^2 E^2 + (4m_p E - m_\Lambda^2 + m_p^2)(m_\Lambda^2 - m_p^2 - Q^2)] - 2C_V B_V Q^2 (m_\Lambda + m_p) [(m_\Lambda - m_p)^2 - Q^2] + 2C_A B_A Q^2 (m_\Lambda - m_p) [(m_\Lambda + m_p)^2 - Q^2] - 2[C_V C_A + C_A B_V (m_\Lambda + m_p) - C_V B_A (m_\Lambda - m_p) - B_V B_A (m_\Lambda^2 - m_p^2)] Q^2 [-4m_p E + m_\Lambda^2 - m_p^2 - Q^2] \}. \quad (5)$$

The threshold for reaction (1) in the laboratory system is $(m_\Lambda^2 - m_p^2)/2m_p = 194$ Mev, and, up to the threshold for Λ photoproduction ($e^- + p \rightarrow e^- + \Lambda + K^+$), which is equal to $[(m_\Lambda + m_K)^2 - m_p^2]/2m_p = 912$ Mev, reaction (1) is the only source of Λ hyperons (together with $e^- + p \rightarrow \Sigma^0 + \nu$, $\Sigma^0 \rightarrow \Lambda + \gamma$).

The matrix element for process (1) (in the notation introduced in reference 3) has the form (where we ignore the electron mass)

$$M = (\bar{u}_\Lambda \{ \gamma_\alpha (C_V - C_A \gamma_5) - \sigma_{\alpha\beta} (p_\Lambda - p_p)_\beta (B_V + B_A \gamma_5) \} u_e) \times (\bar{u}_\nu \gamma_\alpha (1 + \gamma_5) u_e), \quad (2)$$

with the form factors C_V , C_A , B_V , B_A functions of the square of the momentum transfer

$$-Q^2 = (p_p - p_\Lambda)^2 = 2m_p W + (m_\Lambda - m_p)^2, \quad (3)$$

where W is the kinetic energy of the Λ hyperon in the laboratory system. If E is the energy of the incident electron and $\epsilon \equiv 2m_p E + m_p^2$ is the total energy in the center-of-mass system then

$$0 \leq -Q^2 \leq 2m_p E \left(1 - \frac{m_\Lambda^2}{\epsilon^2} \right) = \epsilon^2 \left(1 - \frac{m_p^2}{\epsilon^2} \right) \left(1 - \frac{m_\Lambda^2}{\epsilon^2} \right). \quad (4)$$

The cross section for process (1) for a given E and Q^2 is given by*