(iii) Semileptonic decays $Y \to e\nu X$ of charmed mesons have multihadronic decay products, with $m_X \sim 1$ GeV for $m_Y \sim 2$ GeV. This is indicated by distributions of Y-decay products in $\nu \to \mu^- e^+$ and $e^+e^- \to e+$ hadrons experiments.

(iv) Heavy lepton production is still needed to explain the SPEAR $e\mu$ events.

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QUARK-GLUON THEORY AND NONLEPTONIC DECAYS

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1. Light Quarks and the $\Delta I = 1/2$ Rule

We would like to propose a new mechanism for $\Delta I = 1/2$ rule in nonleptonic decays[1]. The point is that the effective Hamiltonian contains the induced scalar-(pseudo)-scalar interaction

$$H^{eff}(\Delta S=1) = \sqrt{2}\, G_F \sin\theta_c \cos\theta_c\, C\, [\bar{s}_L u_R \bar{u}_R d_L + \bar{s}_L d_R \bar{d}_R d_L + \bar{s}_L s_R \bar{s}_R d_L] + \dots \quad (1)$$

$$\psi_{L,R} = 1/2\,(1 \pm \gamma_5)\,\psi$$

where u, d, s stands for corresponding quark fields. On the other hand the matrix elements from densities are large if quark masses are small, e.g.,

$$\langle 0|\bar{u}\gamma_5 d|\pi\rangle = (i/(m_u+m_d))\langle 0|\partial_\mu(\bar{u}\gamma_\mu\gamma_5 d)|\pi\rangle = i f_\pi m_\pi^2/(m_u+m_d) \quad (2)$$

To our understanding the most motivated estimate[2] of masses is as follows[x]

$$m_u \approx m_d \approx 5\ MeV; \quad m_s \approx 150\ MeV \quad (3)$$

In this case matrix elements from (1) are greatly enhanced and this is the mechanism for explanation $\Delta I = 1/2$ rule. To test the idea quantitatively we use

a) asymptotic freedom at short distances to calculate coefficient C in eq. (1) and

b) quark model of hadrons to calculate the matrix element from $H^{eff}(\Delta S=1)$.

We proceed now with a brief description of results obtained. Simplest graph giving rise to term (1) within quark-gluon theory of strong interactions is presented in Fig. 1 and the corresponding value of C is equal to

$$C^{(1)} = \frac{4}{3}\,\frac{g^2}{16\pi^2}\,\ln\frac{m_c^2}{m^2} \quad (4)$$

where g is quark-gluon coupling constant, m_c is charm quark mass and m is some hadronic mass.

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[x] It is worth emphasizing that m_u, m_d do not necessary coincide with "physical" quark masses and are used here only as measure of $SU(2)\otimes SU(2)$ symmetry breaking. Quarks can acquire mass through spontaneous symmetry breaking (at price of massless pion) even in the limit $m_u = m_d = 0$.

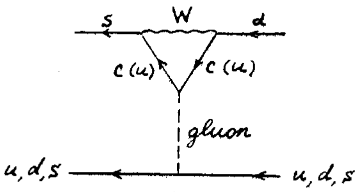

Fig. 1

Using the renormalization group technique (for the case of weak interactions used first in Ref. /3/) the leading log terms can be summed in all orders. The results depend on parameters:

$$C = \begin{cases} 0.25 \text{ if } m_W = 70 \text{ GeV}, \; m_c = 2 \text{ GeV}, \\ \qquad m = 0.7 \text{ GeV}, \; g^2(m^2)/4\pi = 1 \\ 0.54 \text{ if } m_W = 100 \text{ GeV}, \; m_c = 2 \text{ GeV}, \\ \qquad m = 0.14 \text{ GeV}, \; g^2(m^2)/4\pi = 1 \end{cases} \qquad (5)$$

Our consideration refer not only to term (1) but accounts for all other possible structures (the total number of operators being equal to seven). The final result is that the operator (1) is very essential.

When estimating the matrix elements we assume that nucleon consists of three quarks and mesons are bound states of quark-antiquark. The quark graphs for hyperon decay are examplified on Fig. 2a,b. The contribution of the first

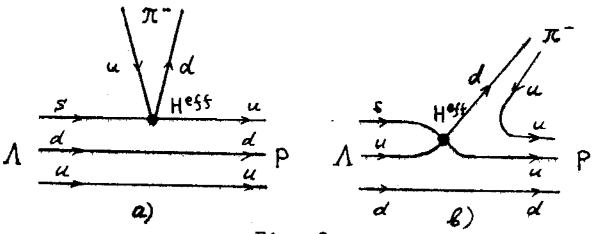

Fig. 2

one can be expressed in terms of matrix elements of leptonic decays and quark masses. The following relation arises

$$\frac{\sqrt{3}\,B(\Lambda^0_-) - B(\Sigma^+_0)}{\sqrt{3}\,A(\Lambda^0_-) - A(\Sigma^+_0)} = g_A \,\frac{m_\Xi + m_\Sigma}{m_\Xi - m_\Sigma} \simeq 25 \qquad (6)$$

where we use the notation of Ref. /4/. This relation does not receive the contribution from graphs of the type 2b. Prediction (6) is in an exellent agreement with experimental value of 27.4±1.0.

From absolute values of amplitude $\sqrt{3}A(\Lambda^0_-) - A(\Sigma^+_0)$ we extract phenomenological value of coefficient C, $C_{ph} \approx 1.0$ (compare with estimates (5)). With this value of C we find that the contribution of Hamiltonian (1) is comparable to experimental values of amplitudes for all hyperon decays. The remaining difference can be due to other structures in Hamiltonian which contribute mainly through the graphs of type 2b. We can predict only the sign of this contribution and find that it is correct.

Using coefficient C_{ph} we calculate amplitude of $K_S \to 2\pi$ decay and find an agreement with the data.

2. $\Delta I = 3/2$ Transitions

Amplitude with $\Delta I = 3/2$ are calculable both for hyperon and K-meson decays in terms of the matrix elements of leptonic decays. The predictions agree with the data both in sign and in magnitude in all the cases, where the data are accurate enough (K and Λ-decays).

3. Right-Handed Currents

The discussion above refers to any model with left-handed currents only. For the models with the current of the type $\sin\varphi\, \bar{c}_R \gamma_\mu s_R$ /5/ the most critical is the calculation of coefficient C_T defined as

$$H^{eff}(\Delta S=1) = \sqrt{2}\, G_F \sin\theta_c \sin\varphi\, C_T\, i\bar{s}_R \sigma_{\mu\nu} \lambda^a d_L\, b^a_{\mu\nu} \qquad (7)$$

where $b^a_{\mu\nu}$ is gluon field-strength tensor, λ^a (a =1,...,8) are colour SU(3) matrices. An analogous term contributes to radiative decays (of $\Sigma \to p\gamma$ kind)

$$H^{eff}_\gamma(\Delta S=1) = \frac{e}{16\pi^2}\sqrt{2}\, G_F \sin\theta_c \sin\varphi\, C_\gamma\, i\,\bar{s}_R \sigma_{\mu\nu} d_L F_{\mu\nu} + (8)$$

In the lowest order

$$C_T^{(1)} = \frac{g}{16\pi^2} m_c \;; \quad C_\gamma^{(1)} = \frac{2}{3} m_c \qquad (9)$$

The account for higher order gluon corrections to the coefficients is rather complicated and requires calculation of two-loop graphs. Here we give final results

$$C_T = C_T^{(1)} \varkappa_2^{-2/27} \varkappa_1^{-14/3b} \Big[1 + \frac{1}{19}(\varkappa_1^{38/3b} - 1) + \frac{5}{11}(\varkappa_1^{11/3b} - 1)\Big] \approx 0.75\, C_T^{(1)} \qquad (10)$$

$$C_\gamma = C_\gamma^{(1)} \varkappa_2^{-4/27} \varkappa_1^{-16/3b} \Big[1 - \frac{32}{13}(\varkappa_1^{13/3b} - 1)\Big] \approx (0.1 \div 0.3)\, C_\gamma^{(1)}$$

where

$$\varkappa_1 = \frac{g^2(m_c^2)}{g^2(m_W^2)} = 1 + b\,\frac{g^2(m_c^2)}{16\pi^2}\ln\frac{m_W^2}{m_c^2}$$

$$\varkappa_2 = \frac{g^2(m^2)}{g^2(m_c^2)} = 1 + 9\,\frac{g^2(m^2)}{16\pi^2}\ln\frac{m_c^2}{m^2}$$

and $g(p^2)$ is effective charge, $b = 11 - \frac{2}{3}N$, N - number of flavours. Note that coefficient at largest power of $\varkappa_1$ is very small (1/19).

Thus there is no enhancement of nonleptonic decays and some suppression of radiative decays.

We have also calculated the gluon corrections to the K_L, K_S mass difference and found for right handed current coupling constant

$$\sin\varphi \lesssim 1/10 \qquad (11)$$

provided that strange quark mass is given by eq. (2). It is follows from this bound that contribution of right-handed currents to nonleptonic decays is small.

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LIMIT ON PARITY VIOLATION IN p-WATER SCATTERING AT 6 GeV/c*

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It has been 20 years since the weak interaction was first demonstrated to violate parity.[1] Since then parity violation has been a very important tool for studying the weak interaction. The present experiment is one of a series which ultimately will result in a direct measurement of the weak interaction contributions to nucleon-nucleon scattering.[2-4]

Two previous experiments have been performed with the 6-GeV/c polarized proton beam at the Argonne ZGS. We measure the transmission of the longitudinally polarized proton beam through a low-Z (water) target as a function of the beam helicity. If the scattering cross section contains the parity-violating term $\vec{s}\cdot\vec{p}$, where $\vec{s}$ is the spin of the incident proton and $\vec{p}$ is its momentum, the transmission will depend on beam helicity. The difference in cross sections is expected to be of order 10^{-5} to 10^{-7} due to the interference between the weak parity-violating amplitude and the strong parity-conserving amplitude.[5] Our first experiment[3] yielded a result for the fractional change in cross section with polarization direction of $(\sigma^+ - \sigma^-)/(\sigma^+ + \sigma^-) = (5 \pm 9) \times 10^{-6}$, where +(-) refers to positive (negative) helicity. The error was dominated by noise in the measurement of the transmission at a level three times that expected from proton statistics. For our second run[4] we concentrated on adding additional measures of the beam properties in order to determine the sources of noise in the transmission measurement. We were only partially successful, but did obtain a nonzero result $(\sigma^+ - \sigma^-)/(\sigma^+ + \sigma^-) = (11 \pm 4) \times 10^{-6}$.

Unfortunately we could not be sure that the observed result is due to a parity-violating nucleon-nucleon interaction since an alternative explanation is available. The effect is consistent with a polarization transfer during hyperon production followed by "normal" parity-violating decays.

Our third experiment has been designed to eliminate the hyperon effect. A schematic diagram of the experiment is shown in Fig. 1. The extracted proton beam is vertically polarized. The magnitude and directinn (which reverses every pulse) are monitored by a polarimeter consisting of two counter telescopes. The beam, after being deflected vertically through 7.75° to rotate the spin to longitudinal, is incident on the front detector system. This system contains detectors to measure the beam intensity, an 80-cm water target, and diagnostic detectors. The scintillation detectors labeled X and Y measure residual transverse polarization of the beam before and after the target. They consist of pairs of scintillation counters which measure any vertically or horizontally asymmetrically scattered beam. The P1 and P2 counters are pairs of wedge-shaped scintillstors which monitor the position of the beam. MON is an ion chamber to monitor the incident beam. DIF1 is an ion chamber which is paired with DIF2 on the rear system as one measure of the transmission. An independent measurement is provided by a pair of scintillators I (in front) and T (in the rear).

In order to insure that only unscattered beam is measured by the T and DIF2 detectors, the transmitted beam is momentum analyzed. The beam transport consists of a collimator, two bending magnets (each of which rotates the proton spin through 90°), and a quadrupole triplet which focuses the beam from the target onto the T counter.

Another pair of diagnostic counters is S, which monitors any beam which scrapes inside the beam transport where the polarization is fully transverse. A final beam position monitor is provided by P3, the beam size is monitored by A, and possible contamination of T by scattered beam is monitored by T'.

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