(1962); M. Islam, Phys. Rev. 131, 2292 (1963).

[3]This arbitrary, but simple, form has been used to fit a number of different experiments in addition to (1). See, for example, G. Goldhaber et al., Phys. Letters 6, 62 (1963); E. Ferrari and F. Selleri, Nuovo Cimento 27, 1450 (1963).

[4]Z. Guiragossián, Lawrence Radiation Laboratory Report No. UCRL-10731, 1963 (unpublished).

[5]F. Selleri (unpublished) has, however, obtained much larger Λ^2 based on the form $F(t) \rightarrow 0.28$ at large negative t. We find this form unsatisfactory as the experiments of Goldhaber and Guiragossián (references 3 and 4) require much smaller form factor at very large $|t|$.

[6]The calculations shown in Fig. 1 for $k_{\pi \mathrm{lab}} = 3.3$ BeV/c indicate that this variation should be significant at small production angles, i.e., $-t < 20 m_\pi^2$.

[7]We are unable to state the direction of the shift in position although it seems reasonable that at high energy the ρ mass will be higher at high-momentum transfer. Small deflections of the pions as they leave the vicinity of the nucleon will, on the basis of phase space, favor higher ρ mass.

[8]Initial- and final-state interactions are mainly absorptive, however, not (we assume) primarily due to iteration of $H_{\pi N \rightarrow \rho N}^{\mathrm{per}}$.

[9]The results that follow can also be obtained from the S-matrix approach by the methods of Omnes and Jackson [R. Omnes, Nuovo Cimento 8, 316 (1958); J. Jackson, Nuovo Cimento 25, 1038 (1962)]. The development is more complicated, however, as the channels into which the absorption goes must be treated explicitly.

[10]A more detailed treatment involving a complex potential shows that this approximation underestimates the suppression of the very low partial-wave amplitudes. The suppression of any amplitude is seen to be at most a factor of $\frac{1}{4}$ [similar calculations were performed at higher energy. There occurs an energy-dependent difference between the pure form-factor curve (a) and the unitarized curve (c) (see reference 2)], which is not small enough for the first one or two partial waves. However, this is sufficient to satisfy the unitarity limit and give a reasonable result for the total amplitude. For orientation, some sample η_l's [that were obtained from (12) using (10)] which we used for our calculation at 3.3 BeV/c are $\eta_0 = 0.20$, $\eta_1 = 0.29$, $\eta_2 = 0.44$, $\eta_3 = 0.61$, $\eta_4 = 0.76$, $\eta_5 = 0.87$, etc.

[11]S. Lindenbaum, Proceedings of the International Conference on Nucleon Structure, Stanford University, Stanford, California, June 1963 (to be published); M. Perl, L. Jones, and C. Ting, Phys. Rev. 132, 1252 (1963).

[12]Y. Lee, B. P. Roe, Daniel Sinclair, and J. C. Vander Velde (to be published).

[13]There is also a shift in position and width depending on the momentum-transfer bin due to the variation of the kinematical minimum of the momentum transfer. For the example shown, this is a completely negligible effect.

[14]Qualitatively, we would expect large spin-orbit coupling in the final state if in strongly absorbed partial waves, the absorption varies significantly from the lth to the $(l+2)$nd wave. There will also be some coupling to the nuclear spin leading to depolarization. At high energies these spin-dependent effects would become small.

[15]W. Walker et al., Phys. Letters 8, 208 (1964).

$\Delta T = \frac{3}{2}$ NONLEPTONIC DECAY

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The relative rates for the decays $K^+ \rightarrow \pi^+ + \pi^0$ ($\Delta T = \frac{3}{2}$) and $K_1^0 \rightarrow \pi^+ + \pi^-$ ($\Delta T = \frac{1}{2}$) give an amplitude ratio of 1/23. It is difficult to understand this as a consequence of electromagnetic violation of a purely $\Delta T = \frac{1}{2}$ weak interaction. [As an illustration, consider the model[1] in which the decay proceeds through successive strong and weak couplings: $K\pi \rightarrow K^* \rightarrow \pi$. On taking into account the electromagnetic mass difference between $K^{*+} - K^{*0}$, with the aid of the theoretical (mass)^2 formula $K^{*+} - K^{*0} = K^+ - K^0$, one obtains the amplitude ratio 1/400.] It has been suggested recently[2] that the $\Delta T = \frac{1}{2}$ decay may be approximately forbidden, while the electromagnetic process is not correspondingly inhibited. We should like to point out that, contrary to this proposal, the observed rate for the $\Delta T = \frac{3}{2}$ nonleptonic decay of K^+ can be obtained from known leptonic decay rates, without invoking electromagnetic effects.

The relevant leptonic decays are $\pi^+ \rightarrow \mu^+ + \bar{\nu}$ and $K^+ \rightarrow \pi^0 + e^+ + \nu$, $\pi^0 + \mu^+ + \bar{\nu}$. They are described by the phenomenological couplings

$$(g_{\pi l}/m_\pi)\pi_\lambda \bar{\psi}_\mu \gamma^\lambda (1 + i\gamma_5)\psi_\nu$$

and, for example,

$$(g_{K\pi l}/m_K m_\pi)[K_\lambda \pi^0 - K\pi_\lambda{}^0 + \xi(K_\lambda \pi^0 + K\pi_\lambda{}^0)] \times \bar{\psi}_\mu \gamma^\lambda (1 + i\gamma_5)\psi_\nu,$$

where particle symbols represent the corresponding boson fields. The coupling constants are

$$g_{\pi l}^{2}/4\pi = 1.77\times10^{-15},$$

$$g_{K\pi l}^{2}/4\pi = 0.747\times10^{-15},$$

while ξ is obtained from the $\pi\mu\nu/\pi e\nu$ branching ratio[3] as

$$\xi = 0.66_{-1.3}^{+0.9} \text{ or } \xi = -6.6_{-1.5}^{+0.7}.$$

Independent experimental evidence that would permit a choice between these alternatives is conflicting.[4] We shall also need the value of the coupling constant for the $(\mu\bar{\nu})(e\nu)$ interaction. It is written as g_{ll}/m_{π}^{2}, with

$$g_{ll}^{2}/4\pi = 2.03\times10^{-15}.$$

We view all boson (and baryon) leptonic decay processes as manifestations of a direct interaction of the bosons with the charged vector field Z_{μ} that is coupled to charged lepton pairs. If the effective coupling constant and mass of an associated Z particle are designated as e' and m_{Z}, respectively, we have the identification

$$g_{ll}/m_{\pi}^{2} = e'^{2}/m_{Z}^{2}.$$

The interaction between the Z field and the bosons is obtained by substituting $\bar{Z}^{\lambda}(m_{Z}^{2}/e')$ for $\bar{\psi}_{\mu}\gamma^{\lambda}(1+i\gamma_{5})\psi_{\nu}$. As a result of this coupling, there is an interaction between the charged components of $K\pi^{0}$ and π. It is

$$(g_{K\pi\pi^{0}}/m_{K})[K_{\lambda}\pi^{0} - K\pi_{\lambda}^{0} + \xi(K_{\lambda}\pi^{0} + K\pi_{\lambda}^{0})]\bar{\pi}^{\lambda},$$

with

$$g_{K\pi\pi^{0}} = g_{K\pi l}\,g_{\pi l}/g_{ll}.$$

This constant has the value given by

$$g_{K\pi\pi^{0}}^{2}/4\pi = 0.651\times10^{-15}.$$

An equivalent form of the $K\pi\pi^{0}$ interaction is

$$g_{K\pi\pi^{0}}m_{K}[1+(\xi-1)(m_{\pi}^{2}/m_{K}^{2})]K\bar{\pi}\pi^{0}.$$

It can be compared[6] with

$$g_{K_{1}\pi^{+}\pi^{-}}m_{K}K_{1}^{0}\pi^{+}\pi^{-},$$

where

$$g_{K_{1}\pi^{+}\pi^{-}}^{2}/4\pi = 5.03\times10^{-14}.$$

Thus, the ratio of the amplitudes is

$$0.114[1+(\xi-1)/12.5],$$

which equals 1/9 for $\xi = 0.66$ and 1/22 for $\xi = -6.6$. The latter is in remarkable agreement with the observed ratio. A reliable experimental decision between the alternative ξ values would now be of particular interest.

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[1]The extension of this K^{*} model to baryons gives a reasonably quantitative picture of all parity-violating $\Delta T = \frac{1}{2}$ nonleptonic decays. It specifically predicts the absence of s-wave pions in $\Sigma^{+}\to n+\pi^{+}$; the s-wave amplitudes for the various baryon decays are related by the sum rule given recently, on quite different grounds, by B. W. Lee, Phys. Rev. Letters 12, 83 (1964); similarly defined coupling constants for $(\bar{N}^{0}\Sigma^{-})\pi^{+}$ and $(\bar{K}^{0}\pi^{-})\pi^{+}$ agree to within 25%.

[2]N. Cabibbo, Phys. Rev. Letters 12, 62 (1964).

[3]D. Luers, I. S. Mittra, W. J. Willis, and S. S. Yamamoto, Phys. Rev. 133, B1276 (1964).

[4]See the summary by V. A. Smirnitski and A. O. Weissenberg, Phys. Rev. Letters 12, 233 (1964). The ξ values of +2 and -9 refer to earlier branching-ratio measurements.

[5]This is the implication of a new field theory of matter (to be published). It is described briefly by Julian Schwinger, Phys. Rev. Letters 12, 237 (1964).

[6]The comparison is merely a convenient way of expressing the absolute rate predicted for $K^{+}\to\pi^{+}+\pi^{0}$. The dominant $\Delta T = \frac{1}{2}$ decay process is attributed to highly excited meson states coupled through the charged Z field, which produce the virtual transition $K_{1}^{0}\to$ vacuum, or the weak coupling $K^{*}\to\pi$ $(\Delta T = \frac{1}{2})$. A discussion of the dynamical origin of approximate selection rules in strong, electromagnetic, and weak interactions is in preparation.