cludes all powers of β_2 and β_4. This expansion was cut off in the calculations after $L = 4$, which means that the terms neglected in the second-excited-state scattering amplitude were $O(\beta_4\beta_2^2)$ and $O(\beta_2^4)$.

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CP INVARIANCE IN WEAK INTERACTIONS AND THE PION DECAY ASYMMETRY*

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All known particle reactions, whether they be strong, electromagnetic, or weak, are in accordance with *CP* invariance, with the notable exception of the recent experimental results of Christenson, Cronin, Fitch, and Turlay[1] on the apparent decay of K_2^0 mesons into two pions with a branching ratio of 2.3×10^{-3}. Several explanations of this effect may be proposed, which take account of the fact that this apparent *CP* nonconservation is "very small." They include the following:

(1) External fields not invariant under *CP* of *TCP*. Such a mechanism could make the long-lived component have a small admixture of K_1^0, thus leading to a small two-pion mode. The smallness of the apparent *CP* nonconservation is then due to the smallness of these external fields,[2,3] say due to a very weak long-range coupling of hypercharges, or the local density of neutrinos.[4]

(2) "Maximal" *CP* nonconservation in a rare decay channel. Either the $\Delta I = \frac{3}{2}$ part of the nonleptonic decay amplitude[5] or the $I = \frac{3}{2}$, $\Delta Q = -\Delta S$ leptonic decay amplitude[6] could be chosen to fit the role.

(3) The reinterpretation of the decay modes as decay into two particles, at least one of which differs in spin-parity assignment from the pion. Since Christenson et al. measured the masses of the two particles rather carefully, we must assume that such particle (or particles) is degenerate with pions in mass.

In a recent investigation, two of us have found some evidence for a small but significant correlation between the direction of emission of the decay muon and the initial direction of emission of the pion produced in the τ-decay mode of K^+ mesons. Elsewhere[7] these two authors have announced this effect (the Bakunine effect) and presented a brief analysis of the experimental data. If we believe in the existence of such a genuine correlation, at least some of these "pions" must possess spin, but have nearly the same mass as the usual pseudoscalar pion.

We therefore propose that a new particle, called the spion (spinning pion), is involved in the "two-pion" mode of K_2^0 and (some of) the "three-pion" mode of K^+. *CP* nonconservation is no longer implied by the observation of Christenson et al.; and the observed π-μ decay correlations would be explained.

Such a decay mechanism would have several direct experimental tests:

(i) The spion would be expected to have more or less equal rates for decay into the electron and muon leptonic modes.[8] The π-μ decay asymmetry could be explained by an admixture of at least 5% of spions in τ decay; we therefore expect that at least 3% of all the "pions" from τ's decay into electrons.[9]

(ii) The muons (and electrons) from spion decay would be polarized oppositely to those from pion decay. Hence, in particular, we would expect the muons from the two-meson decay of K_2^0 to exhibit a polarization different from the polarization of muons from pion decay.

(iii) Since at least one of the mesons in the Christenson experiment is a spion, the electron decay mode would be expected to be quite frequent (between 25 and 50%).

(iv) If the spion occurs only in the charged form, the $\Delta I = \frac{1}{2}$ rule would be violated by several percent in τ decay. If neutral spions exist, they are forbidden to decay into two photons if their spin is 1; in such a case the preferred mode will be decay into an electron-positron pair plus a photon. There will thus be an anomalous number of Dalitz pairs.

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[8]At present we are measuring this branching ratio from our sample of τ decays.
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DETERMINATION OF THE $\Delta_\delta^{++}-\Delta_\delta^{0}$ MASS DIFFERENCE

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The $\Delta_\delta^{++}-\Delta_\delta^{0}$ mass difference has been found to be -0.45 ± 0.85 MeV. This measurement is compared to an SU(6) prediction and to various dynamical theories of SU(3) splitting.

It is well known that the particle masses of an isotopic spin multiplet are split by electromagnetic effects. Within an SU(3) supermultiplet general relationships may be derived between these electromagnetic mass differences.[1] More specific predictions of these splittings may be made with dynamical models such as the "tadpole" model of Coleman and Glashow[2] or the calculation of Socolow[3] which uses only known particles. The agreement with experiment of these predicted mass differences has been quite satisfactory with the pseudoscalar and baryon octets[2]; thus it would be of interest also to test the decuplet mass-splitting predictions.

Accurate measurements of the decuplet masses are difficult for the following reasons:

(1) Rather large statistics are required since the Δ_δ, Σ_δ, and[4] Ξ_δ have level widths comparable to or larger than the electromagnetic mass differences.

(2) Σ_δ and Ξ_δ are not seen experimentally in two-body reactions of the form

$$m+B\to B^*\to m+B,$$

but must be studied in production reactions such as

$$m+B\to m+B^*\to m+m+B.$$

In production reactions the exact position of the B^* on the Dalitz plot has no simple relation to its mass, but depends on the largely unknown details of the production mechanism. However, if charge-symmetric reactions are studied, mass differences may, in principle, be measured.[5]

Although the width of the Δ_δ is about two orders of magnitude larger than the accuracy to which we wish to determine its mass, we have the advantage that there already exists a large body of experimental data on Δ_δ formation from low-energy pion-nucleon scattering experiments. The reactions which have been extensively studied are

$$\pi^+ + p\to\Delta_\delta^{++}\to\pi^+ + p;$$
$$\pi^- + p\to\Delta_\delta^{0}\to\pi^- + p$$
$$\to\pi^0 + n.$$

Thus by an analysis of these reactions we hope to determine, among other things, the $\Delta_\delta^{++}-\Delta_\delta^{0}$ mass difference.

For two reasons we have used only total cross-section measurements in our analysis. First, statistical accuracy is assured since the beam-attenuation measurement is the simplest and most often performed scattering experiment.[6] Second, the nonresonant partial waves contribute incoherently to the total cross section, thus minimizing their effect upon the dominant resonant state.

The experimental data are taken from the compilation of Klepikov, Meshcheryakov, and Sokolov,[7] with the addition of several later experiments.[8] These data have been fitted to an expression of the following form:

$$\sigma_{\rm tot}(\pi^+p)=\sigma_r+c_{3/2}\sigma_b(\tfrac{3}{2});$$
$$\sigma_{\rm tot}(\pi^-p)=\tfrac{1}{3}\sigma_r+\tfrac{1}{3}c_{3/2}\sigma_b(\tfrac{3}{2})+\tfrac{2}{3}c_{1/2}\sigma_b(\tfrac{1}{2}).$$

The meanings of the individual terms are as follows[9]:

$$\sigma_r=8\pi\lambda^2\frac{(\Gamma/2)^2}{(m-m_0)^2+(\Gamma/2)^2},$$