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ψ(3095) DECAYS INVOLVING KAONS[*]

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ABSTRACT

Some specific decay modes of the ψ(3095) involving kaons have been studied to provide information on the SU_3 character of the new meson. The data favor an SU_3 singlet assignment of the ψ(3095) although quantitative tests do not agree with the hypothesis of a pure state and exact SU_3 conservation.

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The meson ψ(3095), referred in the following as ψ, being an I=0 state[(1)] can in principle be either an SU_3 singlet, or the eight component of an octet, or a mixture of both.

It has been emphasized [2)] that the SU_3 character of the ψ can be tested by studying certain exclusive decay channels, especially those involving kaons. In particular, if SU_3 is conserved in the decay process, then an SU_3 singlet ψ is forbidden to decay into two mesons belonging to the same SU_3 multiplet or more generally belonging to two multiplets whose $I_3 = Y = 0$ members have the same charge conjugation quantum number. This rule then forbids the decay of such a singlet into $K^0\bar{K}^0$, $K\bar{K}^*(1420)$ and $K^*(892)\bar{K}^*(892)$ while it allows such modes as $K\bar{K}^*(892)$, $K^*(892)\bar{K}^*(1420)$.

The tests presented here have been undertaken with approximately 150,000 hadronic decays of the ψ recorded in the SLAC-LBL magnetic detector [3)] at SPEAR. This sample corresponds to an integrated luminosity of 140 nb^{-1}.

<u>Search for the Decay into K_SK_L</u>

In the sample of 2-prong events having opposite charge, the invariant mass is computed assuming both particles to be pions. Fig. 1a shows a clear signal at the K^o mass. For the events with 470 MeV/c^2 < $m_{\pi\pi}$ < 520 MeV/c^2, the missing mass recoiling against the possible K_S is plotted in Fig. 1b. Three events, compatible with the background present under the K_S peak, are seen in the region of the K^o mass within the experimental resolution. The detection efficiency for a K_SK_L decay is found by a Monte Carlo calculation to be (25 ± 3)%. This leads to a 90% confidence limit for the branching fraction of:

$$\frac{\psi \to K_S K_L}{\psi \to \text{all}} < 0.8 \cdot 10^{-4}$$

A limit of 6×10^{-4} has been reported for the mode K^+K^-.[4)]

Search for the Decays into KK*

These decays can be studied for different charge states and various configurations of 2 or 4 tracks detected in the apparatus. Each configuration relative to a given decay mode has its own detection efficiency and its own systematic problems, thus the analysis provides a direct check of internal consistency.

In the 4-prong events which conserve the total momentum within 100 MeV/c we have looked for the decay $K_S K^\pm \pi^\mp$ by first selecting a K_S going into $\pi^+\pi^-$ ($m_{\pi^+\pi^-}$ within ± 30 MeV of the K^o mass). Of the two remaining charged prongs the $K^\pm$ is chosen such that the mass of the system $K_S K^\pm \pi^\mp$ falls within 50 MeV of m_ψ. In the selected sample the masses $K^\pm\pi^\mp$ and $K^o_S\pi^\mp$ are reconstructed and the result is shown on the two-dimensional plot of Fig. 2a. Most of the events accumulate in two bands indicating the formation of $K^{*o}(892)$ and $K^{*\pm}(892)$. The two bands are roughly equally populated as predicted for the direct decay of an I = 0 state. Assuming SU_3 conservation, a decay via an intermediate photon would have given a ratio 4 to 1 between the two intensities. There is no corresponding evidence for the decays into $KK^*(1420)$.

In the 2-prong events with missing momentum greater than 200 MeV/c, one can search for the mode $K^\pm\pi K^o_{miss}$ when the K^o is not seen. For this decay it is necessary to rely on the time-of-flight information to identify the kaon in order to lower the background. The cut used keeps 90% of the kaons while rejecting 85% of the pions. Figure 2b shows the scatter plot of the mass $K^\pm\pi^\mp$ versus the mass $K^o\pi^\pm$. Again here one notices the accumulation of events along the bands corresponding to $K^*(892)$ formation. The background comes from the channel $\pi\pi KK$ with two prongs escaping detection.

Table 1 summarizes the results for the different detected modes corresponding to the decay $\psi \to KK^*$, with their detection efficiency and the number of events seen in each channel. The results are consistent and have been averaged to give the branching fractions of the last column.

Search for the Decays into K^*K^*

The mode $\psi \to \pi^+\pi^-K^+K^-$ has also been detected in the sample of 4-prong events conserving the total momentum within 50 MeV/c. Again the time-of-flight is used in order to identify the kaons. With a total of 203 events the branching ratio is found to be:

$$\frac{\psi \to \pi^+\pi^-K^+K^-}{\psi \to \text{all}} = (4.0 \pm 1.2)10^{-3}$$

The somewhat large error reflects the uncertainty in the production mechanism and in the estimate of the acceptance. The events corresponding to $\phi\pi^+\pi^-$ with $\phi \to K^+K^-$ have been rejected. In the remaining sample one can reconstruct the invariant masses corresponding to the neutral combinations $K^\pm\pi^\mp$. Figure 3 shows the mass $K^+\pi^-$ plotted versus the mass $K^-\pi^+$. The different K^*K^* channels are evaluated and the results are listed in Table 1. The data shows that the decay of the ψ into two identical K^* seems suppressed while the decay into $K^*(892)K^*(1420)$ is observed. Recalling the observation of the decay into $KK^*(892)$ and the non-observation of the channels K_SK_L and $KK^*(1420)$ one concludes that there is a systematic suppression of decay modes prohibited for an SU_3 singlet having C = -1 while decay modes that are allowed are indeed seen.

This indicates that SU_3 is operative and that the ψ behaves in these decays like a singlet as required for a $c\bar{c}$ bound state. However a pure SU_3 singlet state is predicted to give equal decay rates into $\pi^+\rho^-$, $K^+K^{*-}(892)$ and $\eta^8\omega^8$ where η^8 and ω^8 denote the pure octet combinations. This gives the following relative intensities for the physical channels, after correction for phase space and $\phi\omega$ mixing:

$$\pi^+\rho^- : K^+K^{*-}(892) : \phi\eta = 1 : 0.85 : 0.50$$

The experimental branching ratios[1,5] are respectively:

$$(.43 \pm .10)10^{-2} : (.11 \pm .025)10^{-2} : (.04 \pm .02)10^{-2}$$

The disagreement with the SU_3 singlet prediction cannot be explained by interference with the amplitudes arising from the electromagnetic decay proceeding through a virtual photon: assuming SU_3 conservation for this process, it gives the same relative amplitudes as does a singlet state. Therefore we conclude that, either SU_3 is broken in the decay process, or the ψ is not a pure state. In this last hypothesis the observed discrepancy could be accounted for if one assumes a mixture of approximately 20% octet amplitude in the dominantly singlet amplitude of the ψ.

We wish to thank F. Gilman for his numerous suggestions.

References

1. B. Jean-Marie <u>et al</u>., Phys. Rev. Lett. <u>36</u>, 291 (1976).
2. H. Harari, SLAC-PUB-1514 (unpublished); F. J. Gilman, Invited Talk, <u>IV International Conference on High-Energy Physics and Nuclear Structure</u>, Santa Fe, June 9-13, 1975; SLAC-PUB-1600; V. Gupta and R. Kogerler, Phys. Lett. <u>56B</u>, 473 (1975).
3. A. M. Boyarski <u>et al</u>., Phys. Rev. Lett. <u>34</u>, 4 (1975).
4. W. Braunschweig <u>et al</u>., Phys. Lett. <u>57B</u>, 297 (1975).
5. The analysis of the $\phi\eta$ decay will be given in a forthcoming article.

Table Caption

Summary of the analysis for the decays of ψ into strange mesons. Branching ratios for the decays of K_S and K^* are not included in the detection efficiency.

Figure Captions

1a. Invariant $\pi^+\pi^-$ mass for the sample of 2-prong events

1b. Missing mass recoiling against two pions with $470 < m_{\pi\pi} < 520\ MeV/c^2$

2a. Invariant masses $K^\pm\pi^\mp$ vs. $K_S\pi^\pm$ in the decay $\psi \to K_SK^\pm\pi^\mp$ with $K_S \to \pi^+\pi^-$

2b. Invariant masses $K^\pm\pi^\mp$ vs. $K^o\pi^\pm$ in the decay $\psi \to K^oK^\pm\pi^\mp$ with missing K^o

3. Invariant masses $K^+\pi^-$ vs. $K^-\pi^+$ in the decay $\psi \to \pi^+\pi^-K^+K^-$

TABLE 1

Decay Modes	Channel Analyzed	Detection Efficiency	Number of Events	Branching Ratio
K_SK_L	$\pi^+\pi^-$ K^o_{miss}	0.36	< 3	$< 0.8 \cdot 10^{-4}$
$K^o\bar{K}^{*o}(892)$ + $\bar{K}^oK^{*o}(892)$	$K_SK^* \to \pi^+\pi^-, K^\pm\pi^\mp$	0.24	44	$(2.2 \pm .5)10^{-3}$
	$K^oK^* \to K^o_{miss}, K^\pm\pi^\mp$	0.07	28	
$K^+K^{*-}(892)$ + $K^-K^{*+}(892)$	$K^\pm K^* \to K^\pm, K_S\pi^\mp$	0.21	44	$(2.2 \pm .5)10^{-3}$
	$K^\pm K^* \to K^\pm, K^o_{miss}\pi^\mp$	0.06	19	
$K^o\bar{K}^{*o}(1420)$ + $\bar{K}^oK^{*o}(1420)$	$K_SK^* \to \pi^+\pi^-, K^\pm\pi^\mp$	0.12	< 5	$< 1.4 \cdot 10^{-3}$
$K^+K^{*-}(1420)$ + $K^-K^{*+}(1420)$	$K^\pm K^* \to K^\pm, K_S\pi^\mp$	0.10	< 3	$< 1.4 \cdot 10^{-3}$
$K^{*o}(892)\bar{K}^{*o}(1420)$ + $\bar{K}^{*o}(892)K^{*o}(1420)$	π^+K^-, π^-K^+	0.06	30	$(5.5 \pm 2.3)10^{-3}$
$K^{*o}(892)\bar{K}^{*o}(892)$	π^+K^-, π^-K^+	0.09	< 5	$< 0.6 \cdot 10^{-3}$

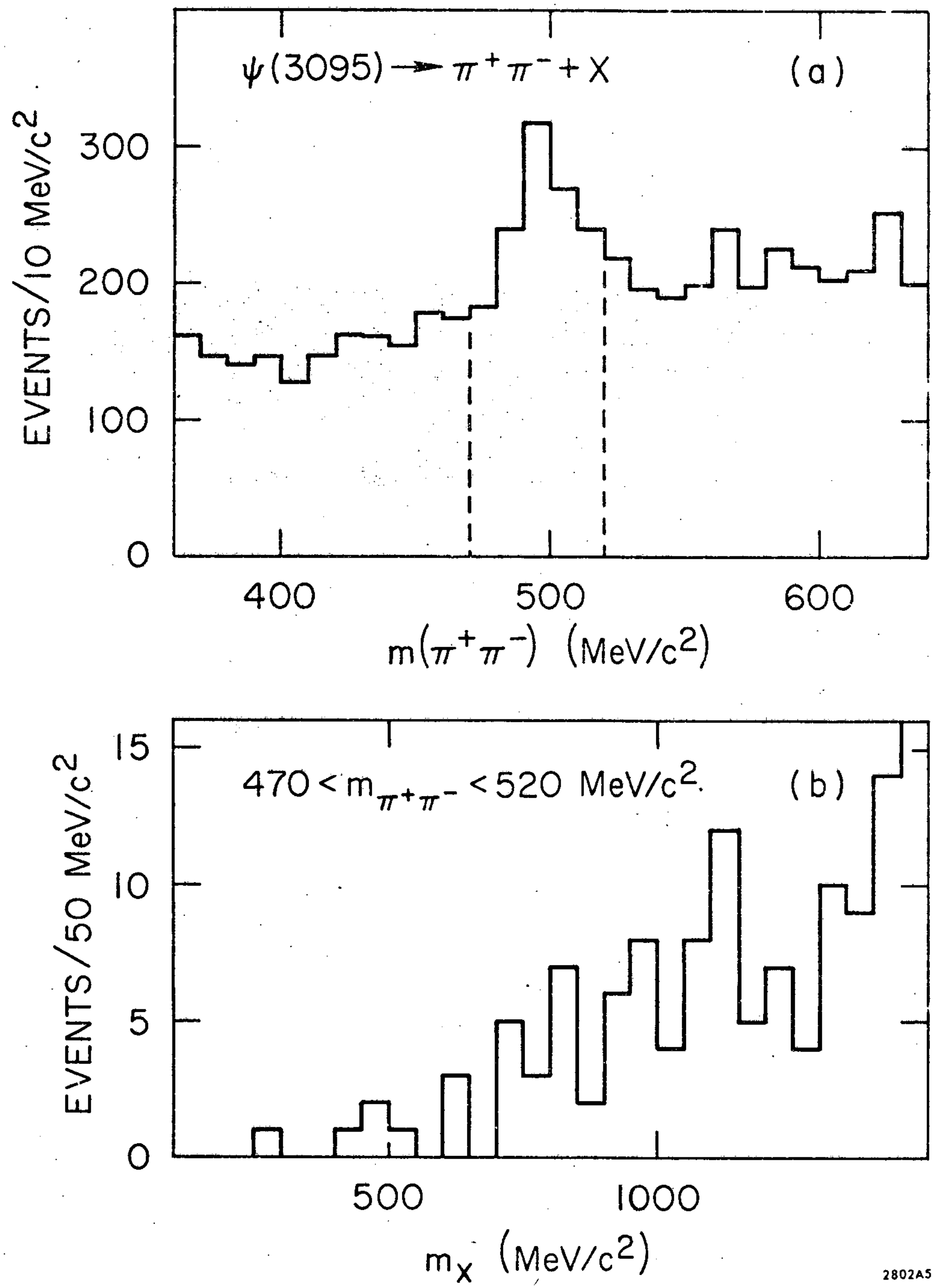

Figure 1

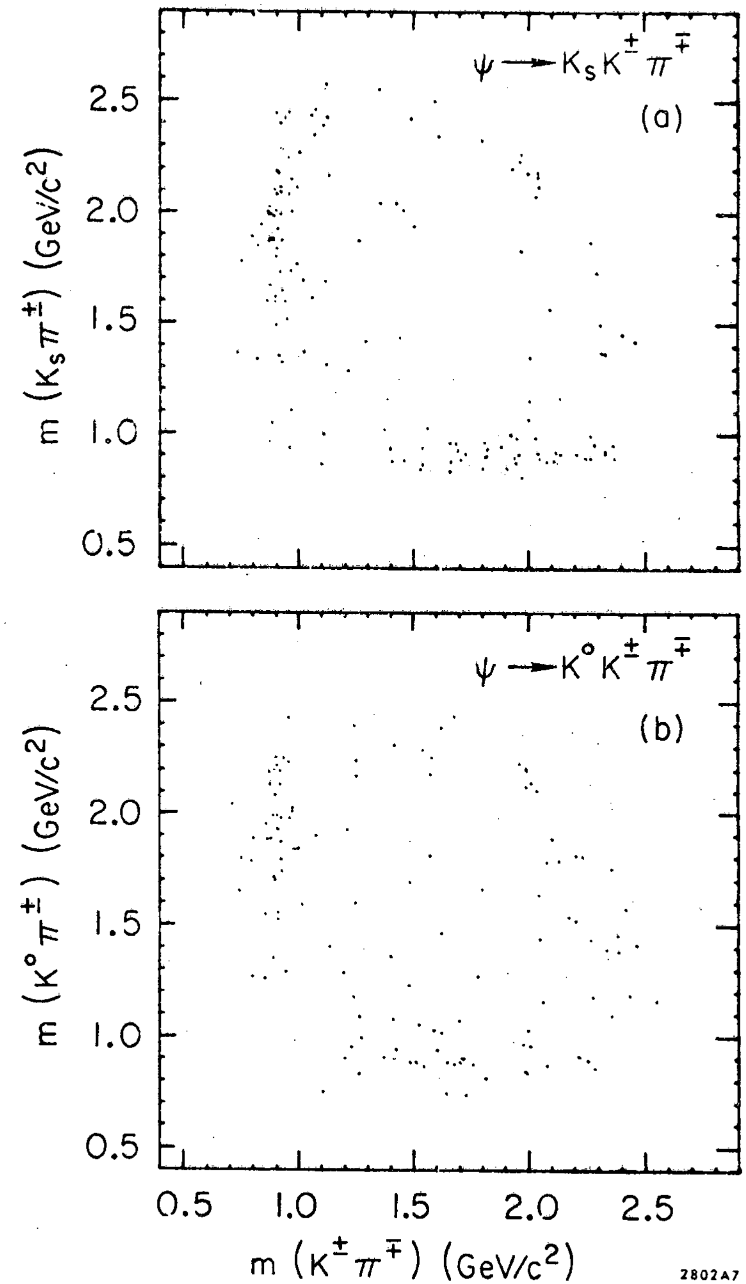

Figure 2

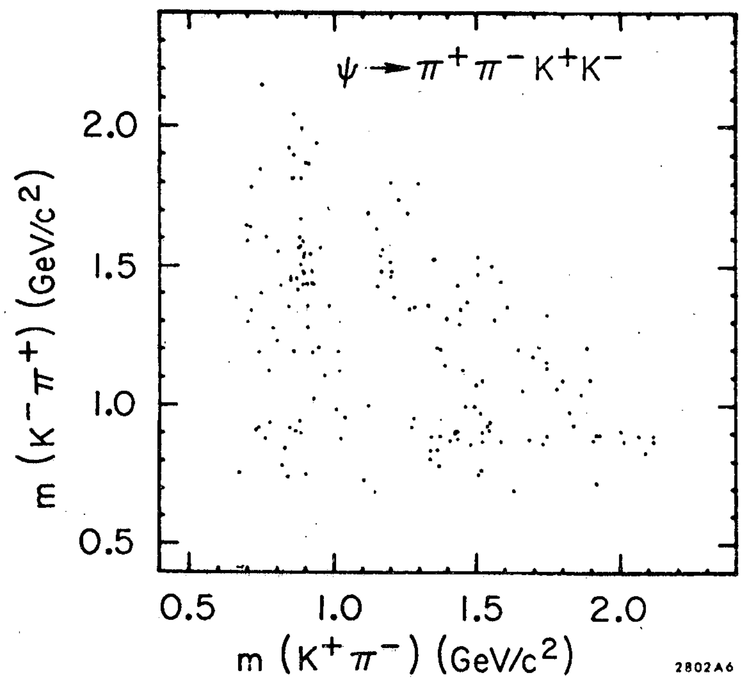

Figure 3

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