STRUCTURE IN THE $K\bar{K}$ DECAY MODE OF THE A_2 MESON

M. AGUILAR-BENITEZ, J. BARLOW, L. D. JACOBS, P. MALECKI *, L. MONTANET and M. TOMÁS **
CERN, Geneva, Switzerland

M. DELLA NEGRA, J. COHEN-GANOUNA, B. LÖRSTAD
Collège de France, Paris, France

and

N. WEST
Nuclear Physics Research Laboratory, University of Liverpool, UK

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Evidence from the $K\bar{K}$ decay mode for the splitting of the A_2 meson is presented.

Convincing evidence has been presented for a splitting of the A_2 meson [1]. The A_2 was produced in π^-p interactions and the relevant mass distribution was calculated from the momentum spectrum of the proton. A good fit was obtained with a dipole interpretation, i.e. :

$$N(M^2) = \frac{4\,(M^2 - M_o^2)^2\, M_o^2\, \Gamma_o^2}{[(M^2 - M_o^2)^2 + M_o^2\, \Gamma_o^2\,]^2}$$

with :

$$M_o = [1298 \pm 5]\ \text{MeV}$$
$$\Gamma_o = [28 \pm 5]\ \text{MeV}$$

An equally acceptable fit was obtained using two coherent Breit-Wigner amplitudes, but in this case three extra parameters are in general required. A poor fit was obtained with two incoherent Breit-Wigner amplitudes.

Crennel et al. [2], studying the same reaction at 6 GeV/c in a bubble chamber, reported a similar structure in the A_2^- observed decaying into π^- + MM. They suggested, however, that this splitting is associated only with the $\rho\pi$ decay mode and not with the $K\bar{K}$ mode since their observed $K_1^o K_1^o$ mass distribution (389 events) shows a single narrow peak ($\Gamma \approx 21$ MeV) at a mass $M \approx 1311$ MeV. This conclusion is obviously incompatible with the double pole interpretation of the A_2.

* Present address: Institute for Nuclear Research, Cracow.
** Visitor from the Junta de Energia Nuclear, Madrid.

In this paper, we present results on the $K_1^o K^\pm$ decay mode of the A_2 meson, as observed in four experiments on $\bar{p}p$ annihilations. We observe the A_2 in reaction (1).

$$\bar{p}p \rightarrow K_1 K^\pm \pi^\mp \qquad 4452 \text{ events} \qquad (1)$$

These experiments were performed at the CERN PS using the 81 cm Saclay hydrogen bubble chamber and the 2 m hydrogen bubble chamber. Details of the experimental data are given in table 1.

The 1553 events at rest differ from those presented in ref. 3 in the following respects. Events from the first runs have not been included. From the other runs, only those events giving four constraint fits in a restricted fiducial volume were accepted. These selection criteria improved the average mass resolution for the $K_1^o K^\pm$ spectrum at rest. The resolution was estimated from the observed width of the ω meson, (15 ± 1) MeV, for both the events at rest [7] and at 0.7 GeV/c

Table 1

Beam momentum GeV/c	Number of events $K^oK^\pm\pi^\mp$ Reaction (1)	Number of events $K^oK_1^o\pi^o$ Reaction (2)	Reference
0.0	1553	364	[3]
0.7	1563	135	[4]
1.2	740	92	[5]
1.2	605	not yet studied	[6]

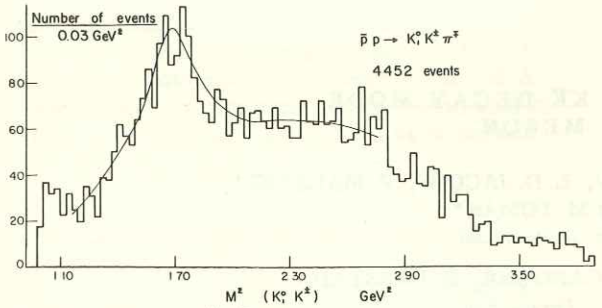

Fig. 1. $\bar{p}p \rightarrow K_1^o K^\pm \pi^\mp$. 4452 events. Total data from annihilations at rest, 0.7 and 1.2 GeV/c. Effective mass squared distribution $K_1^o K^\mp$. Curve corresponds to a fit with a single Breit-Wigner with parameters M_o = 1296 MeV, Γ_o = 129 MeV.

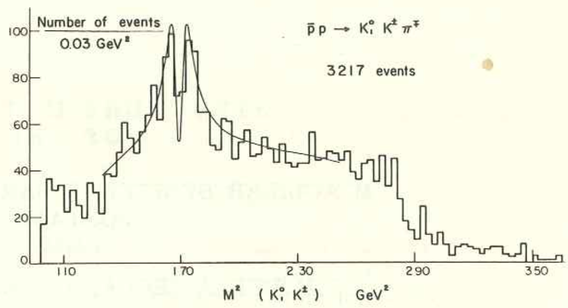

Fig. 2. $\bar{p}p \rightarrow K_1^o K^\pm \pi^\mp$, 3217 events. Total data from annihilations at rest, 0.7 and 1.2 GeV/c. Effective mass squared distribution $K_1^o K^\pm$. For the events from the 0.7 and 1.2 GeV/c experiments the events with $0.745 < M^2 (K\pi) < 0.855$ have been removed. Curve corresponds to a fit with a dipole, $N(M^2) = 4 (M^2 - M_o^2)^2 M_o^2 \Gamma_o^2 / [(M^2 - M_o^2)^2 + M_o^2 \Gamma_o^2]^2$ with M_o = 1303 MeV, Γ_o = 31 MeV.

and from the width of the K_1^o meson produced in reaction (1). The CERN program MILLSTONE was used to displace the K_1^o to the annihilation vertex thus forming a pseudo-four-body event which was then fitted with four constraints. The resolution function was obtained directly as the effective mass distribution of the two pions associated with the K_1^o. For the experiments at rest and at 0.7 GeV/c the full width at half height was (7 ± 2) MeV in the region of the A_2. The resolution at 1.2 GeV/c is not as good: it is of the order of 10 MeV.

We do not present detailed information on the reaction

$$\bar{p}p \rightarrow K_1^o K_1^o \pi^o \qquad (2)$$

because the number of events is small (see table 1): the I = 1 $K\bar{K}$ contribution in reaction (2) is depressed by a factor of at least 6 relative to that of reaction (1) because of isospin coefficients and the probability of observing the $K^o (\bar{K})^o$ decay. Moreover, the neutral spectrum

Table 2

RESULTS

Experiment $\bar{p}$ momentum GeV/c	Type of fit	M_o(MeV)	Γ_o(MeV)	M_2(MeV)	Γ_2(MeV)	Relative Intensities	Confidence Level
0	Dipole	1304 ± 3	32 ± 6	-	-	-	50%
0.7	Dipole	1300 ± 3	26 ± 5	-	-	-	93%
0.7	Incoherent sum of two Breit-Wigners	1278 ± 3	13 + 20 - 5	1314 ± 3	13 + 20 - 5	0.99 ± 0.27	60%
0.7	Single Breit-Wigners	1298 ± 8	69 ± 20	-	-	-	22%
1.2	Dipole	1308 ± 6	29 ± 10	-	-	-	10%
Total	Dipole	1303 ± 2	31 ± 4	-	-	-	65%
Total	Incoherent sum of two Breit-Wigners	1281 ± 3	22 + 10 - 7	1325 ± 3	22 + 10 - 7	0.97 ± 0.01	28%
Total	Single Breit-Wigners	1296 ± 7	124 + 41 - 27	-	-	-	4%

is more complicated than the charged one since it can have isospin zero or one; in particular the presence of the f^0 cannot be excluded.

In fig. 1 we show the total mass squared $(K\bar{K})^{\pm}$ spectrum. A broad enhancement, the A_2, is observed between 1.5 and 1.9 GeV^2. The solid curve in fig. 1 corresponds to a χ^2 fit using a Breit-Wigner distribution and a fifth order polynomial as an approximation to the background: we did not attempt to fit the threshold enhancement nor the high mass region.

In fig. 2 we have improved the A_2 to background ratio by removing events within the K^* bands ($0.745 < M^2(K\pi) < 0.855$ GeV^2) at 0.7 and 1.2 GeV/c. For $\bar{p}$ at rest this selection was not made, mainly because the A_2 is observed [3] in strong interference with the K^* and therefore the cut does not improve the signal to noise ratio. If the $K\bar{K}$ decay mode of the A_2 has the same two peak structure as that observed in ref. 1, with our statistics and mass resolution we should expect to observe such a structure in our data. Indeed, fig. 2 shows an effect which is compatible with this assumption, having a significance of 3 σ. Clearly, the statistical significance of such a narrow effect can be reduced by the binning; it can be made to go down to 1.5 σ. Associating the $K\bar{K}$ peaks with the A_2 meson decaying into three pions determines the G parity to be -1. This, in turn, restricts the spin parity to the series 2^+, 4^+, ... Under these assumptions the most likely spin parity is 2^+. Therefore, we fit the data using again a fifth order polynomial approximation to the background and a dipole interpretation for the resonance region; the solid curve shown in fig. 2 is the result of this fit.

The parameters obtained in the fit are displayed in table 2 where the confidence levels quoted are for the restricted mass squared region $1.49 < M^2[K\bar{K}] < 1.85$ GeV^2. In fig. 3a, we show this restricted region with curves corresponding to the dipole and single Breit-Wigner fits already mentioned. It is clear that our data are compatible with the dipole hypothesis. Different spin-parities for the two peaks are allowed if they are not associated with three pions. The incoherent sum of two Breit-Wigners is then a valid hypothesis. The result of this fit is shown in fig. 3a, and the parameters are given in table 2. Our data are also in agreement with this hypothesis.

In order to demonstrate that the double-peaked structure is not generated by the summation of different experiments, we show in fig. 3b the $(K\bar{K})^{\pm}$ spectrum for the events from the experiment [4] at 0.7 GeV/c where the effect under analysis

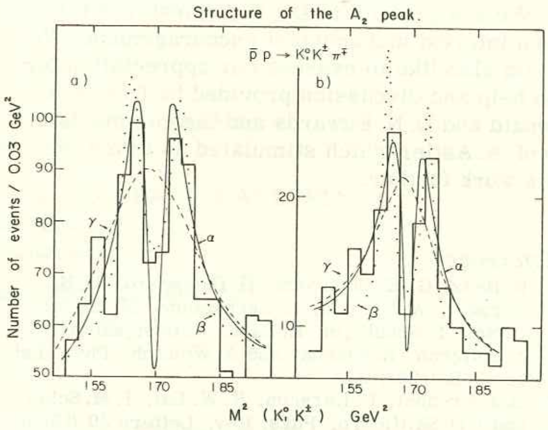

Fig. 3. Effective mass squared distribution $K_1^0K^{\pm}$ in a restricted mass region around the A_2 meson. The curves correspond to the following fits: α) Dipole. β) Incoherent sum of two Breit-Wigners. γ) Single Breit-Wigner.
a) Total data with same cuts as fig. 2.
b) 0.7 GeV/c, events with $M^2(K\pi) > 0.9$ GeV^2.

is most significant. The events shown are those with $M^2(K\pi) > 0.9$ GeV^2. Again we have made the same three fits as we did for the total data. We have used the form for the background as obtained from the fit to the Dalitz plot as a whole. For the region selected, the background differs very little from phase space. A comparison of the fits is shown in table 2, where, again, the confidence levels are for the restricted mass region defined earlier. Fig. 3b shows the results from these three fits. They are clearly compatible with those obtained for the overall data.

In table 2 we also present results from similar fits to the other individual experiments. Within the errors, which are statistical only, these fits are compatible. We have not fclded in the experimental resolution in any of the fits.

Although this $(K\bar{K})^{\pm}$ data does not show unambiguously a splitting of the A_2 meson, it does agree with that obtained in the mass spectrometer experiments of ref. 1. Neither experiment can discriminate between the dipole or the two resonance hypothesis but, if we take for granted that the total A_2 effect decays partially into three pions, our results imply that the parity of the A_2 is positive; the spin parity must be even and bigger than zero, i.e. $J^P = 2^+, 4^+, \ldots$ The simplest hypothesis would be to assume that the total A_2 spin is 2^+, although to verify this a study of angular correlations would be necessary.

It is difficult to reconcile the present results on the K_1^0 $K^{\pm}$ data with those obtained by Crennell et al., on their K_1^0 K_1^0 data.

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