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CLARIFICATIONS ABOUT THE E(1425) MESON QUANTUM NUMBERS

CERN-College de France Collaboration

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Several publications have recently appeared giving new experimental facts on the E(1425) meson ([1], [2], [3], [4], [5]) leading to an apparent contradiction about its spin-parity assignment. As underlined by Chanowitz [6], the results from the π^-p experiment of ref. [4] giving $J^{PC} = 1^{++}$ and those of refs [1] and [2] giving $J^{PC} = 0^{-+}$ and thus substantiating the old $\bar{p}p$ results of ref. [7], indicate the existence of two different states with comparable mass and width.

In this short presentation I would like (a) to recall results which, being perhaps too old, tend to be ignored and (b) to present a reanalysis of the same old data.

The original discovery of the E-meson was made by a CERN-Collège de France Collaboration [8] in the reaction $p\bar{p} \rightarrow E^0 \pi^+ \pi^-$ obtained 19 years ago in $p\bar{p}$ annihilations at rest observed in a hydrogen bubble chamber at the CERN PS. Later on, with increased data, a spin-parity analysis of the E-meson production and decay led to the $J^{PC} = 0^{-+}$ assignment [7] which make it compatible now with a gluonium state.

In ref. [2] using data coming from the Crystal Ball at SLAC, the same quantum number assignment $J_E^{PC} = 0^{-+}$ is found. Their events, although less numerous, have similar distributions than in the CERN-Collège de France

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experiment. The reaction leading to the E being a radiative decay of J/ψ ($J/\psi \rightarrow E\gamma$) makes it a good candidate for a gluonium state. This publication omits mentioning the results and analysis of the CERN-Collège-de-France experiment.

We have reanalysed the data of the CERN-Collège de France [7] using a maximum likelihood method and we confirm the same quantum numbers of the original publication. It must be remembered that the number of our events (873) is a factor 5 to 7 larger than that of ref. [2]. The production reaction of the E, $p\bar{p} \rightarrow K_1^0 K_1^\pm \pi^\pm \pi^\pm \pi^-$, where the spin analysis is done (585 events) is compatible with 100% production of E. The spin-parity assignment comes mainly, as in the SLAC data, from a low mass $K\bar{K}$ accumulation of events in the E-decay. The C-parity +1 is obtained from the observation of $E \rightarrow K_1^0 K_1^0 \pi^0$ decays (83 events).

Table 1 shows the parameters of the maximum likelihood fit. In column 7 we give the values for the 0^{-+} and 1^{++} assumptions. In columns 2-6 we list the imposed mass and width of the E and the branching ratio from the fit. The likelihood function is the logarithm of the hypothesis probability plus a normalisation constant, here about 330.

From this table we see that the drop in probability between 0^{-+} and 1^{++} is enormous. As a check, in column 8 and 9 we give the maximum value of the likelihood function when instead of real events we used Monte Carlo events generated according to fitted parameters of the 0^{-+} and 1^{++} hypotheses. Clearly the 0^{-+} generated events behave like the experimental ones whereas the 1^{++} do not.

In figs 1 and 3 we compare the results of the two fits with the same characteristic distributions. Figs 1(c) and 3(c) show the neutral $K_1^0 K_1^\pm \pi^\mp$ mass distribution: it is well reproduced by both hypotheses. In this plot there are two combinations per event: one resonating, the other not. For an estimation of the shape of the non-resonating combination we used the double charge $K_1^0 K_1^\pm \pi^\pm$ mass combination and subtracted it from the neutral (figs 1(a) and 3(a)). Here also the data are well reproduced and support very well an E production without any background.

In figs 1(b), 1(d), 3(b) and 3(d) we examine the $K\bar{K}$ and $K\pi$ mass distributions when selecting the E. Clearly in the case of 1^{++} the data differ from the fit mainly in the $K\bar{K}$ mass distribution while the fit is reasonably good for the 0^{-+} . The discrepancy between the two hypotheses is more striking in the Dalitz plot of the E-decay, figs 2 and 4. Here we compare the experimental Dalitz plot with those generated by Monte-Carlo for 0^{-+} (fig. 2) and 1^{++} (fig. 4). Only the 0^{-+} reproduces the accumulation of data in the upper right corner of the Dalitz plot. This concentration of data is the best evidence for the 0^{-+} assignement, as it has also been pointed out in ref. [2]. It has to be noticed that the $p\bar{p}$ data show this effect with much higher statistical significance than in ref. [2].

In conclusion, the SLAC experiment [2] confirms the result of the CERN-Collège de France experiment thus establishing that the state found in the radiative decay of J/ψ is the same E-meson discovered in the earlier $p\bar{p}$ experiment. This result makes the E a candidate for a gluonium state.

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TABLE 1

Results of the maximum likelihood

J_{PC} E	Mass MeV	Width MeV	$E \rightarrow K^* K$ %	$E \rightarrow \delta \pi$ %	$E \rightarrow KK\pi$ %	log (Prob)	0^{-+} Assumed log (Prob) expected	1^{++} Assumed log (Prob) expected
0^{-+}	1425	80	43.7	47.8	8.5	292	334	217
1^{++}	1425	60	25.2	27.8	47.	215	218	341

The last two columns are the results of the likelihood on Monte-Carlo events generated accordingly to the result of the fit of real events for the 0^{-+} and 1^{++} hypothesis.

δ parameters: mass 980 MeV width 52 MeV

K^* parameters: mass 891 MeV width 50 MeV

Number of events: 585, coming from the reaction $p\bar{p} \rightarrow K_1^0 K^\pm \pi^\mp \pi^\pm \pi^\mp$,
without cuts.

$$p\bar{p} \rightarrow K_1^0 K^\pm \pi^\mp \pi^+ \pi^- \text{ at rest}$$

Curve are for $J_E^{PC} = 0^{-+}$

Fig. 1

$$1.370 < M(K_1^0 K^\pm \pi^\mp) < 1.450 \text{ GeV}$$

Fig. 2

Fig. 3

$$1.370 < M(K_1^0 K^\pm \pi^\mp) < 1.450 \text{ GeV}$$

Fig. 4