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Charge Exchange Photoproduction and the $a_1(1260)$

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Although recent analyses[1,2] of τ-lepton decay and a reanalysis of hadron production data[2] gave consistent results for the mass of the a_1(~1250 MeV), other results, both experimental[3,4] and theoretical[5], have suggested a significantly smaller value for this parameter. The purpose of this talk is to present our data on the charge-exchange photoproduction reaction, $\gamma p \rightarrow \Delta^{++}\pi^+\pi^-\pi^-$. Our data derive from a hydrogen bubble chamber experiment, performed at SLAC, utilizing incident photons of average energy 19.3 GeV with a full width at half-maximum of 1.7 GeV. The events upon which this talk is based are those which had a kinematic fit to the reaction, $\gamma p \rightarrow p\pi^+\pi^+\pi^-\pi^-$. If we impose the requirement of peripheral Δ^{++} formation ($t'_{\gamma,3\pi}$<0.2 GeV^2), the principal reactions which contribute to this final state are "inelastic" ρ^0 photoproduction ($\gamma p \rightarrow \rho^0 N^{*+} \rightarrow \rho^0\Delta^{++}\pi^-$) and the three-pion-resonance producing reaction, $\gamma p \rightarrow \Delta^{++}(3\pi)^-$. So as to isolate the latter reaction, we remove the $\rho^0 N^{*+}$ events from the sample. The Δ^{++} events which remain have decay angular distributions[6] which are in good agreement with the expectations of the one pion exchange model. Furthermore the neutral dipion spectrum accompanying this Δ^{++} yields a large ρ^0 signal which is in good agreement with a Breit-Wigner distribution with a central mass of 767±5 MeV. This indicates that these ρ^0 are not, in any way, associated with diffractive photoproduction where a poor fit to a Breit-Wigner always results and where the dipion mass spectrum peaks at a dipion mass value less than 740 MeV. The resulting peripheral $\rho^0\pi^-$ spectrum, recoiling from the Δ^{++}, is shown in Figure 1. This spectrum has been corrected for the removal of those $\rho^0 N^{*+}$ events which occupy a common region of phase

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space with the $(3\pi)^-$ production reaction of interest here. Elsewhere[6], we have demonstrated that the large peak around 1300 MeV is consistent with the $a_2(1320)$, both as regards to its mass and width as well as the decay correlations expected if the reaction mechanism is one pion exchange. It is clear that no prominent $a_1(1260)$ signal is present in these data.

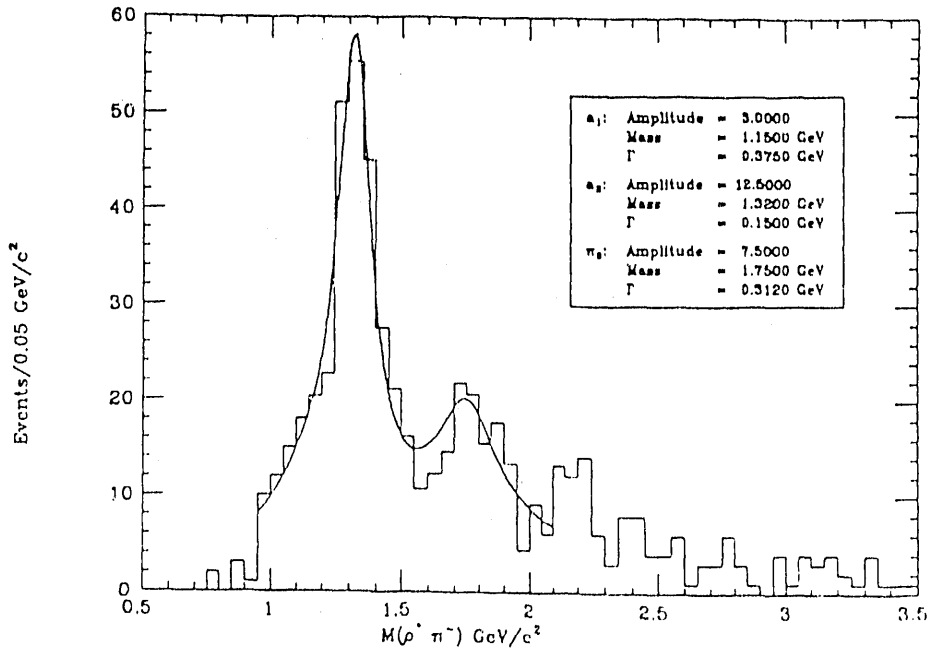

Figure 1.

If we ignore the mass difference between the a_1 and a_2, their relative photoproduction cross sections should be in the ratio of their radiative widths to $\pi\gamma$. Because of a_2 decays to states which do not decay to 3 pion systems, the a_1 should be enhanced in the $\rho^0\pi^-$ spectrum by a factor of ~ 10/7. All previous theoretical and the only experimental result[7] indicate a $\pi\gamma$ width for the a_1 which is at least as large as that of the a_2. If we make the extreme assumption that all of the $\rho\pi$ events with a mass between 0.9 and 1.6 GeV, which are not contained in the a_2 peak, are due to a_1 production we find:

$$\frac{\sigma(\gamma p \rightarrow \Delta^{++}a_1^- \rightarrow \Delta^{++}\rho^\circ\pi^-)}{\sigma(\gamma p \rightarrow \Delta^{++}a_2^- \rightarrow \Delta^{++}\rho^\circ\pi^-)} < 0.4$$

It is difficult to understand this result on the basis of either equal $\pi\gamma$ radiative widths for the a_1 and a_2 or on the basis of their reported experimental values. As mentioned above there have been some recent theoretical[5] and experimental [3,4] work where the idea of a light, relatively narrow a_1 has resurfaced. The smooth curve on Figure 1 is the result of a fit with such an a_1(M=1150MeV, Γ=375MeV) together with an a_2 and another higher mass state over a small background which is quadratic in the mass. The intensity of a_1 production relative to that of the a_2 is ~0.25 which is consistent with the above crude estimate.

In Figure 2 we compare the polar angular distribution for the decay plane normal relative to the incident photon direction (Gottfried-Jackson frame) for the mass regions below the a_1 (0.95-1.2 GeV) and above the a_1 (1.42-1.55 GeV). For t-channel OPE, the expected form of the angular distribution for the a_1 is $(1+\cos^2\theta)$. Interestingly, the low mass region more closely typifies this expectation than does the high mass region.

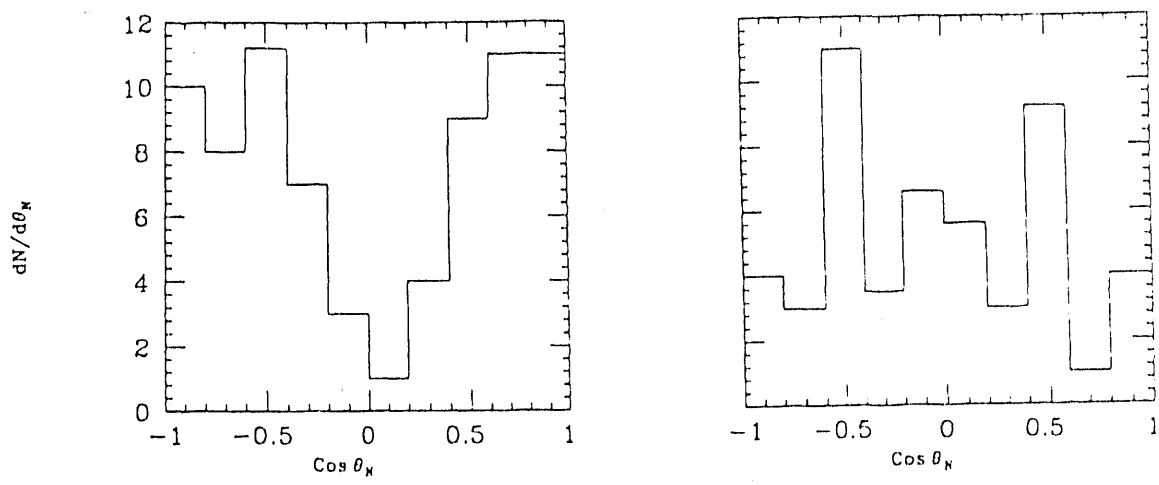

Figure 2.

Another indication that the standard a_1 mass may be too high can be gleaned from the observation of Kamal and Verma[8] that the experimental branching fraction for the decays, $D^0 \to K^- a_1^+$ and $D^+ \to \bar{K}^0 a_1^+$ are factors of six and two, respectively, greater than their calculated values. These authors investigated the consequences of a broad a_1 on these values and found only

marginal effects on the theoretical rate. Since the decay probability of the D's is proportional to $p^3 / m_{a_1^2}$ where p is the a_1 momentum in the D rest frame, it is clear that a lower mass a_1 could result in a significant enhancement in the D decay rate. Thus, e.g., and a_1 mass of 1150 MeV results in an increase of the theoretical rate by a factor of ~3.

In summary, the (3π) mass spectrum from the reaction $\gamma p \rightarrow \Delta^{++}\pi^+\pi^-\pi^-$, is dominated by the presence of the $a_2(1320)$ rather than the $a_1(1260)$. An explanation, which provides a reasonable description of our data, is available from the hypothesis of a light, relatively narrow a_1. This explanation is also consistent with the decay angular distributions.

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*Speaker

[1] N. Isgur, C. Morningstar, and C. Reader, Phys. Rev. D39,1357(1989).

[2] M. Bowler, Phys. Lett. B209,99(1988).

[3] A. Ando et. al., KEK Preprint 90-65, July 1990.

[4] T. A. Armsrong et. al., Zeits. Phys. C. 48,213(1990).

[5] J. Iizuka, H. Koibuchi, and F. Masuda, Phys. Rev. D39,3357(1989).

[6] G.T. Condo et. al., Phys. Rev. D41,3317(1990); Phys. Rev. D43,2787(1991).

[7] M. Zielinski, et. al., Phys. Rev. Lett. 52,1195(1984).

[8] A. N. Kamal and R. C. Verma, Alberta Preprint, Thy-5-91.

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