Title
FURTHER REMARKS ON THE2 PARITY

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Publication Date
1962-04-13
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Berkeley, California
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Robert D. Tripp, Mason B. Watson, and Massimiliano Ferro-Luzzi

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University of California
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ABSTRACT

Answers are given to some recent criticism of the $\Sigma$ parity determination made in this laboratory.
FURTHER REMARKS ON THE $\Sigma$ PARITY

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In a recent unpublished note, R. K. Adair has purported to show that our conclusion of odd $K\Sigma\pi$ parity obtained from a study of the 1520-Mev resonance is quite weak. He accepts the identification of the incoming state as predominantly $S$ wave plus a $D_{3/2}$ resonance, but proposes that the final $\Sigma\pi$ states, instead of being $S$ and $D_{3/2}$ are $P_{1/2}$ and $P_{3/2}$, thereby altering the parity conclusion.

Recall that in our analysis the magnitudes of the nonresonant $S$ wave in $\Sigma\pi$, were determined from the behavior of various total cross sections for $\Sigma^{\pm 0} \pi^{\mp 0}$ production. The resonant-state amplitude and phase were fixed by the Breit-Wigner formula and from a study of the $K\pi$ and $\Lambda 2\pi$ total cross sections. With no free parameters, we could then predict quite well the angular distributions for $K^-p$ and $K^0n$. Now for the $\Sigma\pi$ angular distributions and polarization ($\sin \theta \cos \theta$ term) we had one free parameter at our disposal, the relative phase angle between $S$ and $D$. We adjusted this phase angle to give the best fit to the three angular distributions $\Sigma^+\pi^-$, $\Sigma^-\pi^+$, and $\Sigma^0\pi^0$ and corresponding polarizations. The predictions for these terms were in excellent agreement with experiment for $K\Sigma\pi$ parity odd and in gross disagreement for $K\Sigma\pi$ parity even, which would change the sign of the polarization.

Adair has, however, readjusted the magnitude of the resonant term (now relabeled $P_{3/2}$) retaining the nonresonant $P_{1/2}$ (our $S_{1/2}$) amplitudes but altering their phase with respect to the resonant $P_{3/2}$ in order to get what he considers to be a reasonable fit to the data. To accomplish this, he has also introduced four new parameters: nonresonant $P_{3/2}$ amplitudes and phases in both $I = 0$ and $I = 1$ states. He has thus increased the number of free parameters to five, i.e. the four new ones plus the relative $P_{1/2}$ resonant $P_{3/2}$ phase.
We have recalculated his fits and find some significant discrepancies with his curves. Figures 1 and 2 show the data. The solid lines are our curves as they appear in reference 3 for odd $K\Sigma$ parity. The dashed lines are our calculations for Adair's choice of amplitudes. Figure 3 is a reprint of his Fig. 1 showing his amplitudes. Although he has five free parameters to our one, there is no doubt as to which curves reproduce the data better. For those who are amused by $\chi^2$ tests, the following table gives the $\chi^2$, the expected value of $\chi^2$, and standard deviations for the various proposed possibilities:

<table>
<thead>
<tr>
<th></th>
<th>Our amplitudes</th>
<th>Adair's amplitudes</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\chi^2$</td>
<td>$55$</td>
<td>$95$</td>
</tr>
<tr>
<td>$\chi^2$ expected value</td>
<td>$36$</td>
<td>$36$</td>
</tr>
<tr>
<td>Standard deviations</td>
<td>$2$</td>
<td>$7$</td>
</tr>
<tr>
<td>$\chi^2$ even</td>
<td>$166$</td>
<td></td>
</tr>
</tbody>
</table>

Given the liberty of introducing a small and reasonable amount of non-resonant $P_{3/2}$ amplitude into the $\Sigma\pi$ system, one could reduce our $\chi^2$ of 55 to a more acceptable value. However, in reference 3 we felt the admission of this additional freedom inappropriate.

Finally, Adair seems to have disregarded the vital point that to alter the $\Sigma\pi$ resonant amplitude from our 0.36 to his value of 0.20 does drastic things to the $K^-P$ and $K^0\pi$ resonant amplitudes. These amplitudes are closely related through the Breit-Wigner formula. Figure 4 shows the $K^-P$ and $K^0\pi$ angular-distribution coefficients. The solid curves are our predictions; the dashed curves are predictions from his parameters.

As Adair, we have attempted to find other solutions compatible with the data but, like he, have failed. Perhaps an even-$K\Sigma$-parity solution can be found, but by a process of frustration we have convinced ourselves that this is extremely unlikely.

Although not in the spirit of our previous papers, 2, 3 we further present a semi-quantitative argument to display the overall consistency of our parity assignment. Consider the two reactions:

$$K^-P \rightarrow \Lambda 2\pi$$
$$\rightarrow \Sigma\pi$$

They are in the following ratios to each other at the indicated $K^-$ momenta:
We wish to explain the rapid change in this branching ratio between 300 and 395 Mev/c. Below resonance, both reactions are dominated by the nonresonant incident $S_{1/2}$ amplitudes. Taking the $KP\Sigma$ parity as odd and putting the dipion in an $S$ state, one has for the nonresonant and resonant states:

\[
(K^-P)_S^{1/2} \rightarrow (\Lambda (2\pi) S)^p_{1/2} \quad \text{(nonresonant)}
\]

\[
(K^-P)_D^{3/2} \rightarrow (\Lambda (2\pi) S)^p_{3/2} \quad \text{(resonant)}
\]

For even $KP\Sigma$ parity the states are

\[
(K^-P)_S^{1/2} \rightarrow (\Sigma \pi)^p_{1/2} \quad \text{(nonresonant)}
\]

and

\[
(K^-P)_D^{3/2} \rightarrow (\Sigma \pi)^p_{3/2} \quad \text{(resonant)}
\]

The centrifugal barriers are comparable for the nonresonant and resonant states, and there is no simple mechanism to account for this change in branching ratio. However, for odd $KP\Sigma$ parity, the $\Sigma \pi$ states are $S_{1/2}$ and $D_{3/2}$, respectively. Here, there is a difference of 2 between the orbital-angular-momentum of the nonresonant and the resonant states, the D-wave barrier permitting the $\Lambda 2\pi$ in $P_{3/2}$ to compete effectively against $\Sigma \pi$ in the resonant state.

In conclusion, may we remind Professor Adair that "While a beast which looks like a cow might be a malformed horse, there is much to be said for assuming that it is a cow"? 5

This work was done under the auspices of the U.S. Atomic Energy Commission.
REFERENCES


4. At low energy this is the only likely situation, since the Q value is only 37 Mev. At resonance the enhancement is in I = 0; hence the dipion must be in S or D, and D presents a centrifugal barrier too high for pions at this energy.

Fig. 1
Fig. 2

(a) 

(b) 

(c) 

(d) 

(e) 

(f) 

\[ \frac{P-E}{P+E} \]

\[ K^- + p \rightarrow \Sigma^0 + \pi^0 \]

\[ K^- + p \rightarrow \Sigma^- + \pi^+ \]

\[ K^- + p \rightarrow \Sigma^+ + \pi^- \]

PK (Mev/c)
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