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FURTHER REMARKS ON THE Σ PARITY

Berkeley, California

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Robert D. Tripp, Mason B. Watson, and Massimiliano Ferro-Luzzi

April 13, 1962

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ABSTRACT

Answers are given to some recent criticism of the Σ parity determination made in this laboratory.

FURTHER REMARKS ON THE Σ PARITY

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In a recent unpublished note, R. K. Adair¹ has purported to show that our conclusion of odd $KP\Sigma$ parity² obtained from a study of the 1520-Mev resonance³ is quite weak.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 \bar{K}^0n and $\Lambda 2\pi$ total cross sections. With no free parameters, we could then predict quite well the angular distributions for K^-p and \bar{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 $KP\Sigma$ parity odd and in gross disagreement for $KP\Sigma$ 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 $KP\Sigma$ 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 χ^2 tests, the following table gives the χ^2 , the expected value of χ^2 , and standard deviations for the various proposed possibilities:

	Our amplitudes		Adair's amplitudes
	<u>KP\Sigma odd</u>	<u>KP\Sigma even</u>	<u>KP\Sigma even</u>
χ^2	55	95	166
expected value of χ^2	36	36	32
standard deviations	2	7	17

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 χ^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_n resonant amplitudes. These amplitudes are closely related through the Breit-Wigner formula. Figure 4 shows the K^-P and K^0_n 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- $KP\Sigma$ -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:



They are in the following ratios to each other at the indicated K^- momenta:

P_{K^-} (Mev/c)	$\frac{\Lambda 2\pi}{\Sigma\pi}$ ($\times 10^3$)
0	2 ± 1
300	7 ± 4
395 ^a	200

a. Resonant state only

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 $KP\Lambda$ parity as odd and putting the dipion in an S state,⁴ 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

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REFERENCES

1. R. K. Adair, Sigma Parity, Brookhaven National Laboratory, unpublished work, Feb. 20, 1962.
2. M. Ferro-Luzzi, R. D. Tripp, and M. B. Watson, Phys. Rev. Letters 8, 28 (1962).
3. R. D. Tripp, M. B. Watson, and M. Ferro-Luzzi, Phys. Rev. Letters 8, 175 (1962).
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.
5. R. K. Adair, "The Botany of Strange Particles" in Aix-en-Provence International Conference on Elementary Particles, 1961 (C. E. N., Saclay, 1961).

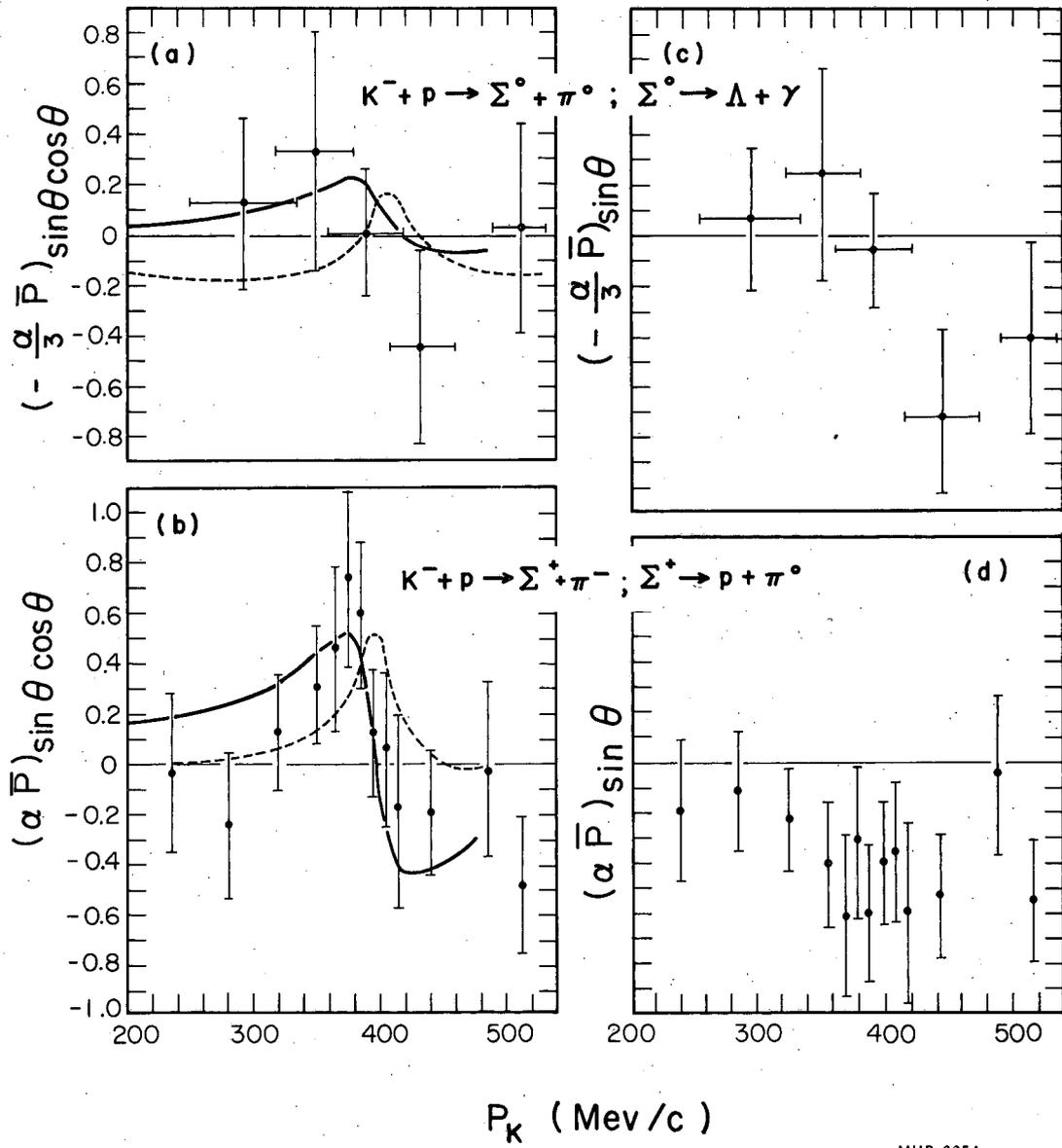
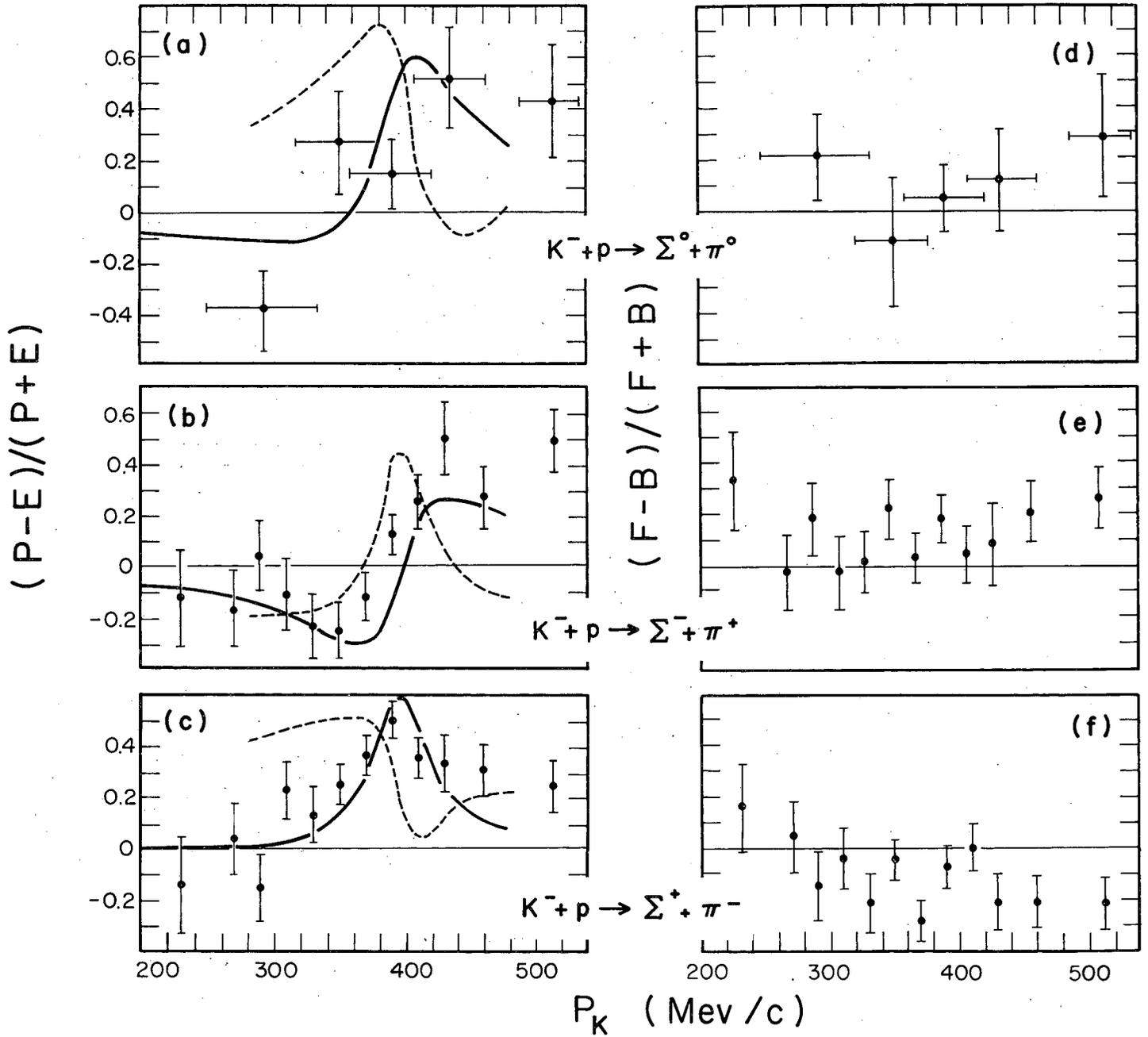
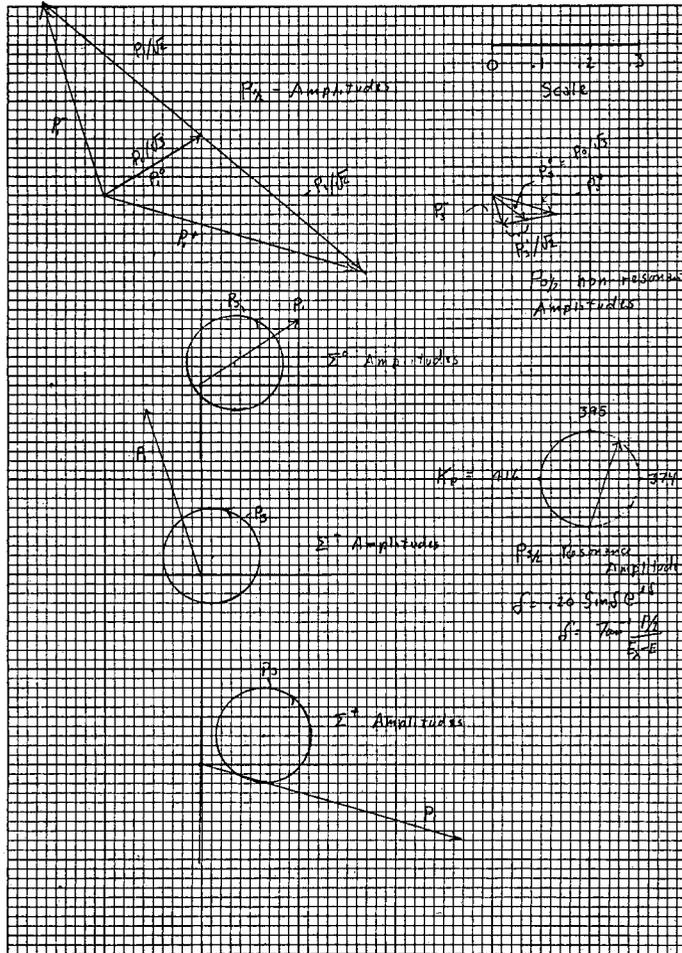


Fig. 1



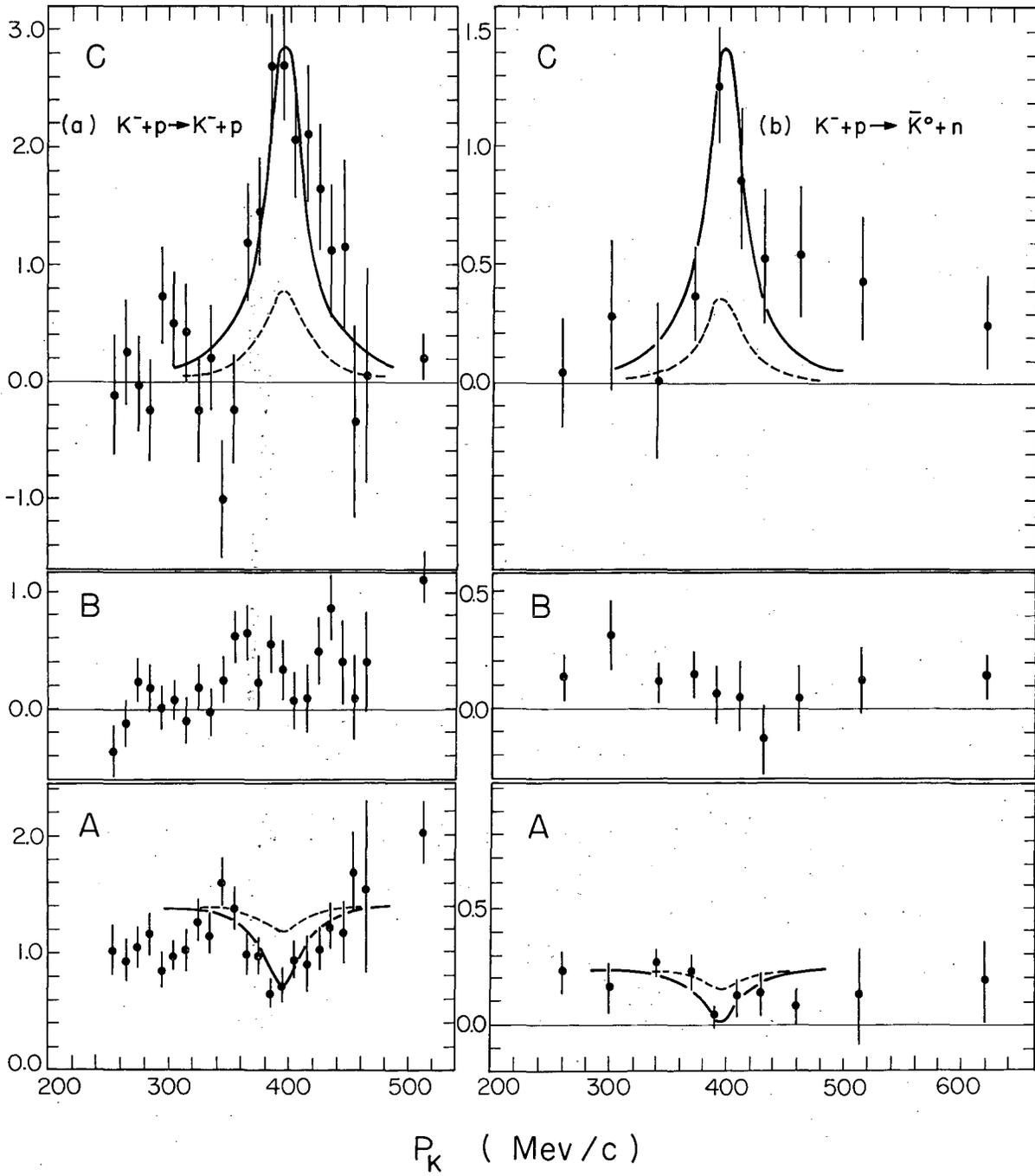
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Fig. 2



MU-26483

Fig. 3



MUB-871A

Fig. 4

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