TEST OF THE t-CHANNEL PARITY EXCHANGE FOR THE REACTION $K^+ + p \rightarrow K^{*0}(1420) + \Delta^{++}$ IN THE QUARK MODEL

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Linear relations between the double statistical tensors describing the decay angular distributions of resonances produced in the reactions $0^- + \frac{1}{2}^+ \rightarrow J^P + \frac{3}{2}^+$ are derived using the additive quark model. Some of these relations enable one to test spin-parity assignment of the produced meson resonance J^P. Others may be used to study the contributions of natural and unnatural exchange in the t-channel. Reaction $K^+ + p \rightarrow K^{*0}(1420) + \Delta^{++}$ at 5 GeV/c is studied and it is found that unnatural parity exchange dominates in this case.

1. *Introduction*

In the previous papers [1, 2] several relations have been derived between the double statistical tensors, describing angular distributions of the resonance decay products in the reactions $0^- + \frac{1}{2}^+ \rightarrow J^P + \frac{3}{2}^+$. Using these relations an attempt has been made to test the spin and parity of the resonance K^{*0} (1420), produced in the reaction $K^+ + p \rightarrow K^{*0}(1420) + \Delta^{++}$ at 5 GeV/c. It has been found that for both $J^P = 2^+$ and $J^P = 3^-$ assignments the quark model relations are in a satisfactory agreement with experimental data. This rises the question: to what extent these relations actually depend on the spin and parity of the produced boson resonance. In the present paper it is shown that for natural or unnatural parity exchange dominance in the t-channel of the reaction $0^- + \frac{1}{2}^+ \rightarrow J^P + \frac{3}{2}^+$ the quark relations between the double statistical tensors may be classified into two groups:

I. Relations depending on spin and parity of the produced meson resonance, valid for any parity exchange (or any parities combination exchange) in the t-channel. The only assumption necessary to derive these relations is that of quark additivity at the baryon vertex. These relations may be used to test spin-parity assignments of the produced meson resonance.

II. Relations valid for any spin and parity of the produced resonance, but different for reactions dominated by natural or unnatural parity exchange. These relations may be used to study natural and unnatural exchange contributions in a given process.

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2. *Relations and comparison with experiment*

For unnatural parity exchange in a quasi two-body reaction $0^- + \frac{1}{2}^+ \to J^P + \frac{3}{2}^+$ all the single spin-flip amplitudes $c_{t_2t_4}$ satisfying conditions $(-1)^{t_2-t_4} = -1$ vanish. Here t_2, t_4 are baryon spin projections on the quantization axis which is chosen perpendicular to the production plane (transversity type frame). On the other hand, the amplitudes $a_{t_2t_4}$, $b_{t_2t_4}$ with non-spin-flip at the baryon vertex are in general different from zero. (Double spin-flip is forbidden in the additive quark model.) Thus for unnatural parity dominance one obtains

$$c_{t_2t_4} \ll a_{t'_2t'_4}, \qquad c_{t_2t_4} \ll b_{t'_2t'_4}.$$

Neglecting quadratic terms $c_{t_2t_4} \cdot c^*_{t_2t_4}$ in the formulae of Ref. [1] expressing the statistical tensors by the amplitudes one obtains the following relations, which are independent of spin J and parity P of the produced meson resonance

$$T^{J_10}_{M_10} = 2T^{J_12}_{M_10}. \tag{1}$$

The assumption of natural parity dominance is expressed by the conditions

$$c_{t_2t_4} \gg a_{t'_2t'_4}, \qquad c_{t_2t_4} \gg b_{t'_2t'_4}.$$

This leads to the relations (in the transversity type frame)

$$T^{J_10}_{M_10} = -T^{J_12}_{M_10}. \tag{2}$$

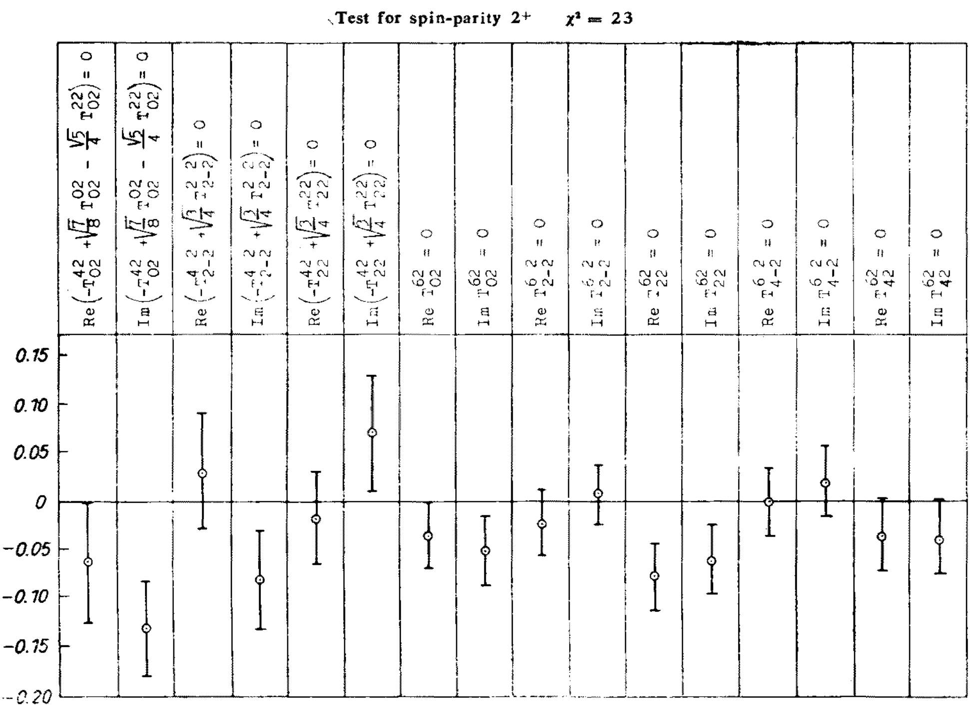

Fig. 1. Experimental values of the left-hand side of the relations for spin-parity 2+ derived in Ref. [3], plotted with their errors

The relations (1) and (2) are independent of spin J and parity P of resonance produced in the reaction $0^- + \frac{1}{2}^+ \to J^P + \frac{3}{2}^+$. If both natural and unnatural parities are exchanged with comparable strength, the relations (1) and (2) are replaced by the more general relation, following only from additivity in the baryon vertex [3]. The relation depending on spin and parity of produced resonance can be derived using the formulae of Refs [1, 2]. Full list of these relations is presented in the Appendix.

In the present work the relations of both types have been used to study the reaction $K^+ + p \to K^{*0}(1420) + \Delta^{++}$ at 5 GeV/c. The results of the comparison of relations of group I which test spin-parity assignment of $K^{*0}(1420)$ with experimental data are inconclusive[1]. These results are shown in Figs 1 and 2. Agreement has been found in both cases ($\chi^2 = 23$ for 15 degrees of freedom, and $\chi^2 = 10.5$ for 11 degrees of freedom for 2^+ and 3^- respectively).

Test for spin-parity 3^- $\chi^2 = 10.5$

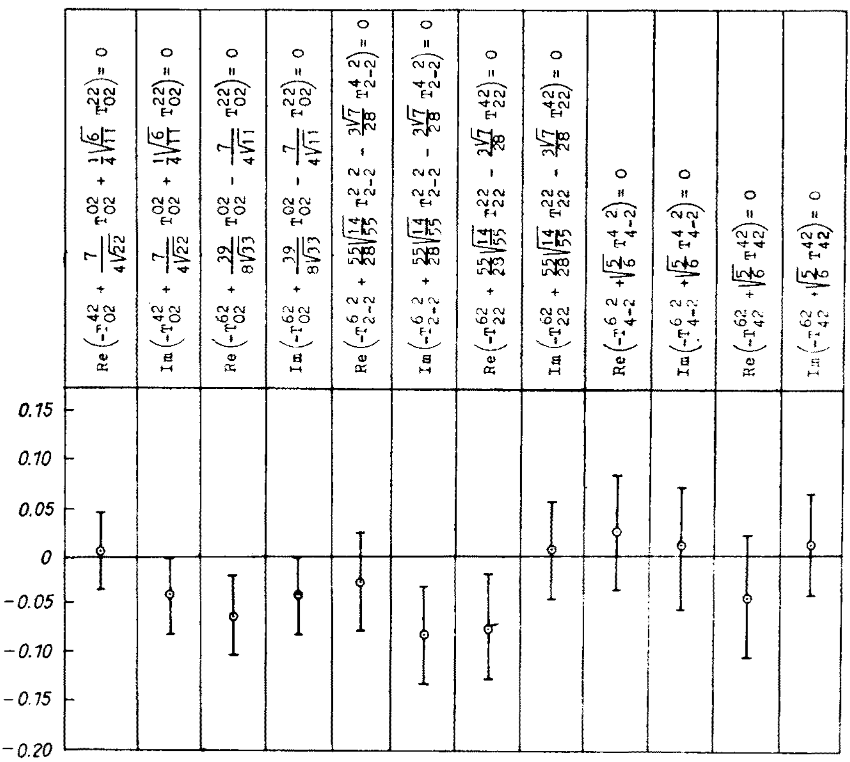

Fig. 2. Same as in Fig. 1 but for spin-parity 3^-

[1] The same situation was found in the previous paper [3]. However there exists some difference between relations presented in the Appendix and relations derived in [3]. If some kind of the parity exchange dominates then the part of relations derived in [3] will be fulfilled trivially owing the equations (1), (2). Because we do not know what kind of the parity is exchanged, it is more reasonable to test the spin-parity assignment of the produced meson resonance using relations depending only on these quantum numbers.

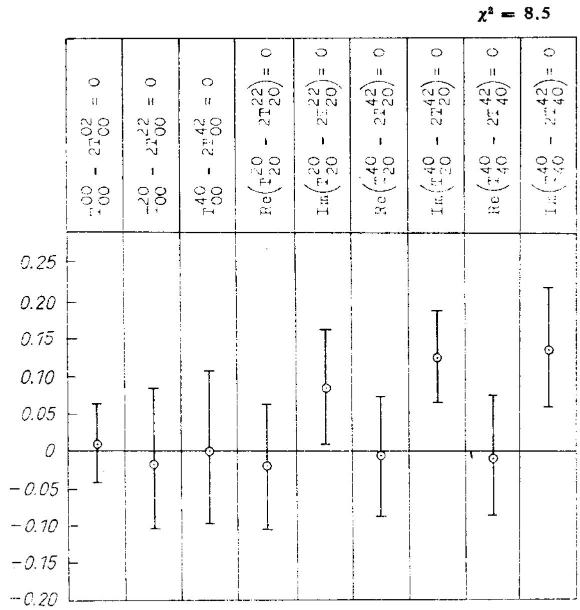

Fig. 3. Experimental values of the left-hand side of the relations $T^{J_1 0}_{M_1 0} - 2T^{J_1 2}_{M_1 0} = 0$ for unnatural parity exchange. They are plotted with their errors

The results of the comparison of type II relations with the experimental data are shown in Figs 3 and 4. It is seen from the figures that the predictions obtained from unnatural parity dominance in the t-channel agree well with the data (the value of χ^2 is 8.5 for 9 degrees of freedom). On the other hand the hypothesis of natural parity dominance is excluded with the confidence level $\alpha < 10^{-4}$ corresponding to $\chi^2 = 305$ for 8 degrees of freedom.

3. *Conclusions*

It is found that linear quark model relations between double statistical tensors may be used to verify:

1. Spin J and parity P of the resonance produced in the reaction $0^- + \frac{1}{2}^+ \to J^P + \frac{3}{2}^+$.
2. Contributions of natural and unnatural parity exchanged in the t-channel.

The first group of relations involves only the additivity assumption of the quark model. Relations of the second group are derived under additional dynamical assumption of the parity exchanged in the t-channel. A test of the second group of relations is performed for reaction $K^+ + p \to K^{*0}(1420) + \Delta^{++}$ at 5 GeV/c and unnatural parity dominance is found. This is consistent with previous results concerning this reaction, obtained by the Bruxelles-CERN Collaboration [4], where it was found that pion exchange dominates the simultaneous production of $K^{*0}(1420)$ and Δ^{++}.

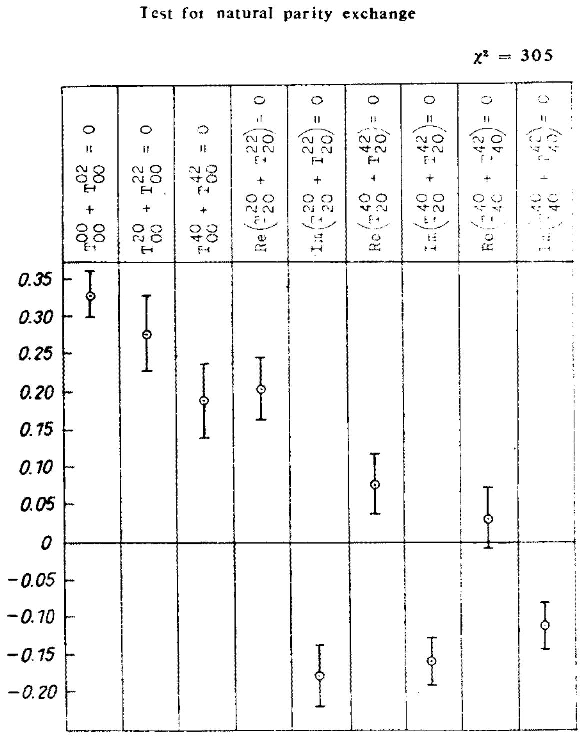

Fig. 4. Same as in Fig. 3 but for relations $T^{J_1 0}_{M_1 0}+T^{J_1 2}_{M_1 0}=0$ for natural parity exchange

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APPENDIX

Quark model relations between the statistical tensor depending on spin and parity of the produced meson resonance

1. Relations for a process of the type $0^-+\frac{1}{2} \to 2^+ + \frac{3}{2}^+$

$$-T^{42}_{02}+\sqrt{\tfrac{7}{8}}\,T^{02}_{02}-\frac{\sqrt{5}}{4}\,T^{22}_{02} = 0,$$

$$-T^{42}_{2-2}+\sqrt{\tfrac{3}{4}}\,T^{22}_{2-2} = 0, \qquad -T^{42}_{22}+\sqrt{\tfrac{3}{4}}\,T^{22}_{22} = 0,$$

$$T^{62}_{02} = 0, \quad T^{62}_{2-2} = 0, \quad T^{62}_{22} = 0, \quad T^{62}_{4-2} = 0, \quad T^{62}_{42} = 0.$$

2. Relations for a process of the type $0^-+\frac{1}{2}^+ \to 3^- + \frac{3}{2}^+$

$$-T_{02}^{42}+\frac{7}{4\sqrt{22}}T_{02}^{02}+\frac{1}{4}\sqrt{\frac{6}{11}}T_{02}^{22}=0,$$

$$-T_{02}^{62}+\frac{39}{8\sqrt{33}}T_{02}^{02}-\frac{7}{4\sqrt{11}}T_{02}^{22}=0,$$

$$-T_{2-2}^{62}+\frac{55}{28}\sqrt{\frac{14}{55}}T_{2-2}^{22}-\frac{3\sqrt{7}}{28}T_{2-2}^{42}=0,$$

$$-T_{22}^{62}+\frac{55}{28}\sqrt{\frac{14}{55}}T_{22}^{22}-\frac{3\sqrt{7}}{28}T_{22}^{42}=0,$$

$$-T_{4-2}^{62}+\sqrt{\tfrac{5}{6}}\,T_{4-2}^{42}=0,$$

$$-T_{42}^{62}+\sqrt{\tfrac{5}{6}}\,T_{42}^{42}=0.$$

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