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USE OF A HELIUM TARGET TO DETERMINE THE SPIN AND PARITY OF MULTIMESON RESONANCES

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As shown in [1], to determine the spin and parity of the boson resonance decaying into three pseudoscalar mesons, it is not sufficient to investigate the angular distribution of the normal to the boson decay plane, but it is necessary also to investigate the distribution of the mesons in the decay plane for each direction of the normal. A similar difficulty is encountered in boson decay into a vector and pseudoscalar meson.

We shall show that if the investigated resonance B is produced in the reaction

$$\Pi + {}^4\mathrm{He} \rightarrow B + {}^4\mathrm{He} \qquad (1)$$

(Π = pion or kaon), then it may turn out that to determine the spin and parity of B it is sufficient to study the angular distribution of the normal to the decay plane of this resonance (in the rest system of B). We can take in lieu of ^{4}He any spinless nucleus, provided the process (1) is not suppressed.

The proposed method, like the methods previously proposed for determining the parities of hyperons and isobars [2-5], is based on the relations between different polarization effects in parity-conserving processes.

Following the method developed in [6] and used in [7], we characterize the process (1) by means of the transition amplitudes $f_m(\vartheta)$, when B is scattered through an angle ϑ in the l.s. and the helicity of B is equal to m.

In analogy with [5,6] we can easily show that

$$f_m(\vartheta) = -\eta(-1)^{j+m} f_{-m}(\vartheta) \qquad (2)$$

where η and j are the parity and spin of B.

As in [5,6], by expressing $f_m(\vartheta)f^*_{m'}(\vartheta)$ in terms of the polarization moments of T_L^M of the boson resonance and taking (2) into account, we reach the conclusion that the T_L^M with even L have in reaction (1) only real parts, while T_L^M with odd L only imaginary parts. We also obtain the following relations between the polarized moments of the resonance B:

$$\sum_{L_{\text{even}}} (2L + 1)\, C^{j(M+M')/2}_{j(M-M')/2, LM}\, T_L^M(\vartheta) = -\eta(-1)^{j+(M'-M)/2} \sum_{L'_{\text{even}}} (2L' + 1)\, C^{j(M+M')/2}_{j(M-M')/2, L'M'}\, T_{L'}^{M'}(\vartheta). \quad (3)$$

For the axes x and y, relative to which the T_L^M are specified, we choose the directions of the momentum p_B of B in the l.s. and of the normal $\vec{n}$ to the plane of reaction (1).

We note that if $\eta = -(-1)^j$ and M = M' the relations (3) become identities, and if $\eta = (-1)^j$ and M = M' relations (3) go over into

$$\sum_{L_{\text{even}}} (2L + 1)\, C^{jM}_{j0, LM}\, T_L^M(\vartheta) = 0. \quad (3')$$

For $\eta = -(-1)^j$ and forward scattering (forward scattering is forbidden if $\eta = (-1)^j$), B can have only zero helicity, and therefore

$$T_L^0(0) = C^{j0}_{j0, L0} \qquad (L \text{ even}). \quad (4)$$

According to [1], the T_L^M are related with the distribution of the normal $\vec{n}$ to the plane of decay of B (in the rest system of B) by the formula

$$T_L^M = \frac{1}{A_L} \langle Y^*_{LM}(\vec{n}) \rangle \qquad (L \text{ even}), \quad (5)$$

where $A_0 = 1/\sqrt{4\pi}$, and the remaining A_L are determined by the dynamics of the decay of B.

We consider two hypotheses.

I. All $A_L \neq 0$. Substituting (5) in (3), we obtain a system of linear equations with respect to $1/A_L$. The number of equations is $(j + 1)(j + 2)/2$ if $\eta = (-1)^j$, and $j(j + 1)/2$ if $\eta = -(-1)^j$. Except for the case j = 1, $\eta = 1$, the number of equations exceeds the number of unknowns, and j and η are obtained from the conditions for the compatibility of the system. If the system cannot be made compatible, then the initial hypothesis is incorrect.

In the case $\eta = 1$, j = 1 we have one equation with unknown A_2. To investigate the hypothesis $\eta = 1$, j = 1 we must additionally produce forward scattering, determine A_2 with the aid of (4), and compare it with the value of A_2 obtained from the first experiment.

II. There exist A_L equal to 0. It is clear that in this case, at least, it is not always possible to establish the spin and parity of B. Thus, if the angular distribution of $\vec{n}$ contains only L = 2 and the first hypothesis has been proved incorrect, then nothing can be said concerning the spin of B other than that $j \geq 2$. If scattering of B through an angle ϑ produces L = 2, 4 in the angular distribution of $\vec{n}$, and if the first hypothesis has been proved incorrect, then $j \geq 3$. We set j = 3, $\eta = -1$, and then obtain 10 equations (3) with nine unknowns: A_2, A_4, and T_6^M (M = 0 ... 6). We are thus able to confirm or reject j = 3,

$\eta = -1$. Investigating the forward scattering of B and recognizing that B is produced in the pure state, we can confirm or reject $j = 3$, $\eta = 1$.

If not all $A_L \neq 0$, then we can investigate the angular distribution of one of the particles produced during the decay of B. All the statements remain valid in this case, too, provided we take $\vec{n}$ to mean a unit vector in the direction of this momentum.

The method presented for determining j and η is usable also in the case of decay of B into a vector and pseudoscalar meson (in this case $\vec{n}$ is a unit vector in the direction of the momentum of the second vector).

We take this opportunity to note that the formulas obtained in [5] can be used to determine not only the parity but also the spin of an isobar.

We note that the use of a spinless target to determine the spin and parity of a boson in the case of two-particle decay was proposed earlier by Bilen'kii and Ryndin [7].

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CHECK OF C-INVARIANCE IN PHOTOPRODUCTION OF STRONGLY-INTERACTING PARTICLES

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We discuss in this note the possibility of checking on the hypothesis concerning C-noninvariance of electromagnetic and strong interactions [1] in experiments with high-energy γ quanta and electrons. Many difficulties arising in the verification of C-invariance in different hadron decays can be circumvented in these experiments.

1. The decay $\pi^0 \to 3\gamma$ is due to C-noninvariant interactions. However, the large centrifugal barriers and the small interaction radii, together with the low energy release, greatly suppress this decay compared with $\pi^0 \to 2\gamma$, in spite of the smallness connected with the emission of the additional γ quantum. This difficulty can be circumvented in principle by investigating the process inverse to $\pi^0 \to 3\gamma$, viz., photoproduction in the Coulomb field of the nucleus of a π^0 meson and a γ quantum (analog of the Primakoff effect [2]). The process $\gamma + Z \to Z + \pi^0 + \gamma$ will have the appearance of the transformation of a high-energy photon in-