SOME SYMMETRY PROPERTIES IN PROCESSES OF ANTIHYPERON PRODUCTION WITH ANNIHILATION OF ANTINUCLEONS

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LET us consider the reaction

$$\tilde{p} + p \rightarrow \tilde{\Sigma}^- + \Sigma^-. \quad (1)$$

We denote the amplitude for it by $f(p_i, p_f, \sigma_p, \sigma_a)$, where p_i and p_f are the relative momenta in the initial and final states, and σ_p and σ_a are the Pauli matrices of the particles and antiparticles. From invariance with respect to charge conjugation it follows that

$$f(\mathbf{p}_i, \mathbf{p}_f, \sigma_p, \sigma_a) = f(-\mathbf{p}_i, -\mathbf{p}_f, \sigma_a, \sigma_p). \quad (2)$$

If the initial state is unpolarized, then it is not hard to prove by Eq. (2) that the polarization vectors of the hyperon (P_Σ) and of the antihyperon ($P_{\tilde{\Sigma}}$) in the final states are given by

$$\mathbf{P}_\Sigma = \mathbf{P}_{\tilde{\Sigma}} = A[\mathbf{p}_i\mathbf{p}_f]/|[\mathbf{p}_i\mathbf{p}_f]|, \quad (3)$$

where A is a function of the scalar $(\mathbf{p}_i \cdot \mathbf{p}_f)$.

Measurement of the angular asymmetries in the decay of the Σ^- and $\tilde{\Sigma}^-$ produced in the reaction (1) gives the ratio

$$\mathbf{P}_\Sigma \alpha_\Sigma / \mathbf{P}_{\tilde{\Sigma}} \alpha_{\tilde{\Sigma}} = \alpha_\Sigma / \alpha_{\tilde{\Sigma}}, \quad (4)$$

where α_Σ and $\alpha_{\tilde{\Sigma}}$ are the antisymmetry coefficients of the decays. As has been shown in reference 1, measurement of the ratio $\alpha_\Sigma / \alpha_{\tilde{\Sigma}}$ is of great significance for testing the conservation laws associated with time reversal T and charge conjugation C; this ratio differs from unity only if T and C are not conserved in the decay.

Let us go on to the consideration of the two cases

$$\tilde{p} + p\,(\tilde{n} + n) \rightarrow Y_1 + \tilde{Y}_2 + m\pi^+ + n\pi^- + l\pi^0 \quad (5)$$

$$\rightarrow \tilde{Y}_1 + Y_2 + n\pi^+ + m\pi^- + l\pi^0. \quad (6)$$

The amplitudes for the reactions (5) and (6) are expressed in the form

$$f_1(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0, \sigma_p, \sigma_a), \quad \alpha = 1, 2, \ldots m, \quad \beta = 1, \ldots n,$$

$$f_2(\mathbf{p}_i, \mathbf{p}_f{}', \mathbf{p}_\beta^+, \mathbf{p}_\gamma^-, \mathbf{p}_\gamma^0, \sigma_p, \sigma_a), \quad \gamma = 1, \ldots l, \quad (7)$$

where $\mathbf{p}^{\pm,0}$ are the momenta of $\pi^{\pm,0}$ mesons. From invariance with respect to C it follows that

$$f_2(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\beta^+, \mathbf{p}_\alpha^-, \mathbf{p}_\gamma^0, \sigma_p, \sigma_a) = f_1(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\alpha^-, \mathbf{p}_\beta^+, \mathbf{p}_\gamma^0, \sigma_a, \sigma_p). \quad (8)$$

Using the relation (8), we get not only equality of the total cross-sections and the angular distributions of these two processes (σ_1 and σ_2), but also equality of the polarization vectors of the hyperons and antihyperons in the final state (P_Y and $P_{\tilde{Y}}$). When the initial state is unpolarized we have

$$\sigma_1(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0) = \sigma_2(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\beta^-, \mathbf{p}_\alpha^+, \mathbf{p}_\gamma^0),$$

$$\mathbf{P}_{Y_1}(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0) = \mathbf{P}_{\tilde{Y}_1}(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\beta^-, \mathbf{p}_\alpha^+, \mathbf{p}_\gamma^0),$$

$$\mathbf{P}_{\tilde{Y}_2}(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0) = \mathbf{P}_{Y_2}(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\beta^-, \mathbf{p}_\alpha^+, \mathbf{p}_\gamma^0). \quad (9)$$

Analogous relations exist also for reactions in which K mesons and nucleons are produced.

There are also a number of selection rules for reactions of the types

$$\tilde{n} + p\,(\tilde{p} + n) \rightarrow Y_1 + \tilde{Y}_2 + m\pi^+ + n\pi^- + l\pi^0$$

$$\rightarrow \tilde{Y}_1' + Y_2' + m\pi^+ + n\pi^- + l\pi^0, \quad (10)$$

where $\tilde{Y}_1'$ and Y_2' are obtained from Y_1 and $\tilde{Y}_2$ by means of the operator G, which is the product of the charge-conjugation operator and a rotation through the angle π around the x axis of the isobaric space.[2] For example

$$\tilde{\Sigma}^- = G\Sigma^+, \quad \tilde{\Sigma}^0 = G\Sigma^0, \quad \tilde{\Sigma}^+ = G\Sigma^-,$$

$$\tilde{\Lambda}^0 = G\Lambda^0, \quad \tilde{n} = Gp, \quad \pi^{\pm,0} = G\pi^{\pm,0}$$

and so on. We denote the respective amplitudes of the reactions (10) by

$f_1(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0, \sigma_p, \sigma_a)$ and $f_2(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0, \sigma_p, \sigma_a)$.

From invariance with respect to G it follows that

$$f_1(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0, \sigma_p, \sigma_a) = \eta f_2(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0, \sigma_a, \sigma_p), \quad (11)$$

where $\eta = \pm 1$ is a phase factor.

It is easy to show from Eq. (11) that for an unpolarized initial state

$$\sigma_1(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0) = \sigma_2(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0),$$

$$\mathbf{P}_{Y_1}(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0) = \mathbf{P}_{\tilde{Y}_1'}(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0),$$

$$\mathbf{P}_{\tilde{Y}_2}(\mathbf{p}_i, \mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0) = \mathbf{P}_{Y_2'}(-\mathbf{p}_i, -\mathbf{p}_f, \mathbf{p}_\alpha^+, \mathbf{p}_\beta^-, \mathbf{p}_\gamma^0). \quad (12)$$

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[1] Chou Kuang-Chao, Nuclear Phys. (in press).

[2] T. D. Lee and C. N. Yang, Nuovo cimento **3**, 749 (1956).

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