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ANGULAR CORRELATIONS IN THE PRODUCTION AND DECAY OF SPIN-3/2 HYPERONS

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ABSTRACT

Simple relationships between the angular distribution in the decay of a spin-$\frac{3}{2}$ hyperon and the directions defined by the production mechanism are obtained for the case in which only final S and P waves contribute to the production process.

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The general expressions given by Spitzer and Stapp in UCRL-3796 (Rev)[1] (hereafter referred to as SS) relating the angular distribution of the decay products of a spin-$\frac{3}{2}$ hyperon to the parameters of the production process may be reduced to a rather simple form if only S and P waves are included.

Let the production cross section be written

$$I(\theta) = A + B \cos \theta + C \cos^2 \theta \quad .$$

Equations (2.13), (2.18), and (2.19) and Tables I and II of SS show that neglecting the $\underset{\sim}{N}$ dependent terms (i.e., averaging over up-down), one may write the decay angular distribution in the form

$$W(\theta, \textcircled{H}, \textcircled{H}') = \frac{1}{4\pi} \Big[1 + I^{-1}(\theta)(\alpha + \beta \cos \theta + \gamma \cos^2 \theta)(3 \cos^2 \textcircled{H}' - 1)$$

$$+ I^{-1}(\theta)(\delta + \epsilon \cos \theta)(3 \cos \textcircled{H} \cos \textcircled{H}' - \cos \theta)$$

$$+ I^{-1}(\theta)\rho(3 \cos^2 \textcircled{H} - 1)\Big] \quad .$$

[1] Richard Spitzer and Henry P. Stapp, Polarization and Angular Correlation in the Production and Decay of Particles of Spin $\frac{1}{2}$ and Spin $\frac{3}{2}$, UCRL-3796 (Rev.), July 1957.

The coefficients α, β, γ, etc. are constants, and the angles are defined (see SS)

$$\theta = \measuredangle \text{ (initial nucleon, hyperon)},$$
$$\textcircled{H} = \measuredangle \text{ (hyperon, final nucleon)},$$
$$\textcircled{H}' = \measuredangle \text{ (initial nucleon, final nucleon)}.$$

This may be reduced to the form

$$4\pi\, I(\theta)W(\theta, \textcircled{H}'; \Phi) = I(\theta) + \left\{\alpha + (\beta + \delta)\cos\theta + (\gamma + \epsilon + \rho)\cos^2\theta\right\}$$
$$\times\ (3\cos^2 \textcircled{H}' - 1) + (\delta + \epsilon\cos\theta)(3\cos\textcircled{H}'\sin\textcircled{H}'\sin\theta\cos\Phi)$$
$$+ \rho(6\cos\textcircled{H}'\cos\theta\sin\textcircled{H}'\sin\theta\cos\Phi)$$
$$+ \rho\sin^2\theta(3\sin^2\textcircled{H}'\cos^2\Phi - 1),$$

where Φ is the azimuthal angle of the final nucleon with respect to a polar axis along the velocity of the initial nucleon ($\Phi = 0$ if $\textcircled{H} = 0$). From Eqs. (2.12), (2.13), and (2.18) and Tables I and II of SS, one verifies

$$\beta + \delta = \frac{1}{2} B ,$$
$$\gamma + \epsilon + \rho = \frac{1}{2}(A + C) - \alpha .$$

Substituting these and averaging over Φ, one obtains

$$4\pi\, I(\theta)W(\theta, \textcircled{H}') = I(\theta)(\tfrac{3}{2}\cos^2\textcircled{H}' + \tfrac{1}{2}) - (A + \rho - 2\alpha)\sin^2\theta(\tfrac{3}{2}\cos^2\textcircled{H}' - \tfrac{1}{2}).$$

If the production angular distribution $I(\theta)$ is known, then the Φ-averaged decay angular distribution is completely determined by the single additional (constant) parameter $(A + \rho - 2\alpha)$. This parameter is positive and is smaller than $\left[A - C + \sqrt{(A + C)^2 - B^2}\right] \leq 2A$. This expression provides a convenient test of the hypothesis that the hyperon has spin-$\frac{3}{2}$. In the limiting case $\sin\theta \to 0$ one obtains the form given by Adair.[2]

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

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2 R. K. Adair, Phys. Rev. 100, 19540 (1955).