The two body hadronic decay of Hyperon with two-thirds spin

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Outline

1. *Introduction*

2. $3/2^+ \to 1/2^+ \ 0^-$

1 *Introduction*

2 $3/2^+ \to 1/2^+ \; 0^-$

baryons with 3/2 spin

Ground states of *uuu*, *ddd*, and *sss* must have spin 3/2

$$\Psi = \psi_{space} \cdot \psi_{spin} \cdot \psi_{flavor} \cdot \psi_{color}$$

- ✓ ψ_{space} : symmetry
- ✓ ψ_{flavor} : symmetry
- ✓ ψ_{color} : asymmetry

so ψ_{spin} must be symmetry, i.e. $s = 3/2$

1 *Introduction*

2 $3/2^+ \to 1/2^+ \ 0^-$

$3/2^+ \rightarrow 1/2^+ \; 0^-$

Example:

- ✓ $\Delta(1232)^{++} \rightarrow N^+ \pi^+$
- ✓ $\Omega^- \rightarrow \Lambda K^-$

1. $L = 1, 2$
   - ✓ P-wave: Parity-conserving
   - ✓ D-wave: Parity-violating

$3/2^+ \rightarrow 1/2^+ \ 0^- \ I$

For $1/2^+ \ 0^- \rightarrow 3/2^+$, the amplitude is (Phys.Rev.D 46 1060 (1992))

$$M = G_F m_\pi^2 \bar{u}^\mu(p_f, \kappa) q_\mu (A + B\gamma_5) u(p_1, s_1) \tag{1}$$

desity matrix:

$$\rho_{\kappa\kappa'} = \frac{1}{4} I + \frac{3}{10} \mathbf{P} \cdot \mathbf{S} + \frac{1}{24} Q^{ij} S^{ij} + \frac{1}{162} R^{ijk} S^{ijk} \tag{2}$$

where **S** is the standard representation of spin-3/2 angular momentum operator,

$$P^i = \frac{1}{3(1+\alpha\hat{\mathbf{p}}_1 \cdot \hat{\mathbf{s}}_1)} [(\alpha + \hat{\mathbf{p}}_1 \cdot \hat{\mathbf{s}}_1)\hat{\mathbf{p}}_1^i + 2\beta(\hat{\mathbf{p}}_1 \times \hat{\mathbf{s}}_1)^i + 2\gamma \hat{\mathbf{s}}_{1T}^i], \tag{18a}$$

$$Q^{ij} = \delta^{ij} - 3\hat{\mathbf{p}}_1^i \hat{\mathbf{p}}_1^j, \tag{18b}$$

$$R^{ijk} = \frac{9}{10(1+\alpha\hat{\mathbf{p}}_1 \cdot \hat{\mathbf{s}}_1)} [3(\alpha + \hat{\mathbf{p}}_1 \cdot \hat{\mathbf{s}}_1)(\delta^{ij} {p_1}^k + \delta^{jk} {p_1}^i + \delta^{ki} {p_1}^j - 5\hat{\mathbf{p}}_1^i \hat{\mathbf{p}}_1^j \hat{\mathbf{p}}_1^k)$$
$$+2\beta\{\Delta^{ij}(\hat{\mathbf{s}}_1 \times \hat{\mathbf{p}}_1)^k + \Delta^{jk}(\hat{\mathbf{s}}_1 \times \hat{\mathbf{p}}_1)^i + \Delta^{ki}(\hat{\mathbf{s}}_1 \times \hat{\mathbf{p}}_1)^j\} + \gamma(\Delta^{ij}\hat{\mathbf{s}}_{1T}^k + \Delta^{jk}\hat{\mathbf{s}}_{1T}^i + \Delta^{ki}\hat{\mathbf{s}}_{1T}^j)], \tag{18c}$$

$3/2^+ \to 1/2^+ \ 0^- \ II$

where $\alpha, \beta, \gamma, \hat{\mathbf{s}}_{1T}$, and Δ^{ij} are defined as

$$\alpha = \frac{2|\mathbf{p}_1|\mathrm{Re}(A^*B)}{E_1(|A|^2+|B|^2)+m_1(|A|^2-|B|^2)}, \tag{19a}$$

$$\beta = \frac{2|\mathbf{p}_1|\mathrm{Im}(A^*B)}{E_1(|A|^2+|B|^2)+m_1(|A|^2-|B|^2)}, \tag{19b}$$

$$\gamma = \frac{E_1(|A|^2-|B|^2)+m_1(|A|^2+|B|^2)}{E_1(|A|^2+|B|^2)+m_1(|A|^2-|B|^2)}, \tag{19c}$$

$$\hat{\mathbf{s}}_{1T} = \hat{\mathbf{s}}_1 - (\hat{\mathbf{p}}_1 \cdot \hat{\mathbf{s}}_1)\hat{\mathbf{p}}_1 = \hat{\mathbf{p}}_1 \times (\hat{\mathbf{s}}_1 \times \hat{\mathbf{p}}_1), \tag{19d}$$

$$\Delta^{ij} = \delta^{ij} - 5\hat{\mathbf{p}}_1^i\hat{\mathbf{p}}_1^j. \tag{19e}$$

$1/2 \to 1/2\ 0$

The amplitude for a spin-1/2 hyperon decaying into a spin-1/2 baryon and a spin-0 meson may be written in the form

$$M = G_F\, m_\pi^2 \cdot \overline{B}_f\, (A - B\gamma_5)\, B_i\ , \tag{96.6}$$

where A and B are constants [1]. The transition rate is proportional to

$$\begin{aligned} R = 1 &+ \gamma\, \widehat{\boldsymbol{\omega}}_f \cdot \widehat{\boldsymbol{\omega}}_i + (1-\gamma)(\widehat{\boldsymbol{\omega}}_f \cdot \widehat{\mathbf{n}})(\widehat{\boldsymbol{\omega}}_i \cdot \widehat{\mathbf{n}}) \\ &+ \alpha(\widehat{\boldsymbol{\omega}}_f \cdot \widehat{\mathbf{n}} + \widehat{\boldsymbol{\omega}}_i \cdot \widehat{\mathbf{n}}) + \beta\widehat{\mathbf{n}} \cdot (\widehat{\boldsymbol{\omega}}_f \times \widehat{\boldsymbol{\omega}}_i)\ , \end{aligned} \tag{96.7}$$

$$\begin{aligned} \alpha &= 2\,\mathrm{Re}(s^* p)/(\,|\,s\,|^2 + \,|\,p\,|^2)\ , \\ \beta &= 2\,\mathrm{Im}(s^* p)/(\,|\,s\,|^2 + \,|\,p\,|^2)\ , \\ \gamma &= (\,|\,s\,|^2 - \,|\,p\,|^2)/(\,|\,s\,|^2 + \,|\,p\,|^2)\ , \end{aligned} \tag{96.8}$$

where $s = A$ and $p = \,|\,\mathbf{p}_f\,|\, B/(E_f + m_f)$; here E_f and $\mathbf{p}_f$ are the energy and momentum of the final baryon. The parameters α, β, and γ satisfy