Hyperon weak radiative decays in the light-front approach

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- **Introduction**
- **Light-front quark model in the hyperon**
- **Hyperon weak radiative decays**
- **Conclusion**

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Hyperon in the particle physice

- A large number of hyperon are producted in various colliders.
- Rich dynamics effect. CP violation, EDM and so on.
  2105.11155, 2307.04364
- A good platform for texting CKM matrix element.
- Precise texting the SM and QCD.

Hyperon weak radiative decays

Puzzle of WRHD

- The parity-violating amplitudes were predicted to be zero for $\Sigma \to p\gamma$ and $\Xi \to \Sigma\gamma$ processes in SU(3) symmetry.

$$\langle B'\gamma|\mathcal{H}(0)|B\rangle = \frac{iG_F}{\sqrt{2}}\bar{u}_{B'}(a+b\gamma_5)\sigma_{\mu\nu}u_B\frac{q^\nu\epsilon^{*\mu}}{m_B},$$

$$Br(B\to B'\gamma) = \frac{G_F^2}{16\pi\Gamma_B}m_B\left(1-\frac{m_{B'}^2}{m_B^2}\right)^3(|a|^2+|b|^2), \quad \alpha = \frac{\Re(a\cdot b)}{|a|^2+|b|^2}.$$

- Confict with the experiment data.

$$\alpha(\Sigma^+ \to p\gamma) = -0.652 \pm 0.056 \pm 0.020.$$

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Hyperon weak radiative decays

The BESIII experiment published its precise measurement of the decay $\Sigma \to p\gamma$.

$$Br(\Sigma^+ \to p\gamma) = (0.996 \pm 0.021 \pm 0.018) \times 10^{-3}$$
$$\alpha(\Sigma^+ \to p\gamma) = -0.652 \pm 0.056 \pm 0.020.$$

This measurement is lower than its world average value by 4.2 standard deviations.

	Br	α
$\Sigma^+ \to p\gamma$	0.996 ± 0.027	-0.652 ± 0.060
$\Lambda \to n\gamma$	0.832 ± 0.066	-0.16 ± 0.11
$\Xi^0 \to \Lambda\gamma$	1.17 ± 0.07	-0.704 ± 0.067
$\Xi^0 \to \Sigma^0\gamma$	3.33 ± 0.10	-0.69 ± 0.06
$\Xi^- \to \Sigma^-\gamma$	0.127 ± 0.023	1.0 ± 1.3

Light-front quark model with three quark picture

Recent years, the LFQM has been explored to the three quark picture. 2212.00300, 2303.02946, 2304.07698

$$
\begin{aligned}
|\mathcal{B}(P,S,S_z)\rangle &= \int \{d^3\tilde{p}_1\}\{d^3\tilde{p}_2\}\{d^3\tilde{p}_3\}2(2\pi)^3\delta^3(\tilde{P}-\tilde{p}_1-\tilde{p}_2-\tilde{p}_3)\frac{1}{\sqrt{P^+}} \\
&\times \sum_{\lambda_1,\lambda_2,\lambda_3} \Psi^{SS_z}(\tilde{p}_1,\tilde{p}_2,\tilde{p}_3,\lambda_1,\lambda_2,\lambda_3)C^{ijk}|q_1^i(p_1,\lambda_1)q_2^j(p_2,\lambda_2)q_3^k(p_3,\lambda_3)\rangle,
\end{aligned}
$$

$$
\begin{aligned}
&\Psi_0^{S=\frac{1}{2},S_z}(\tilde{p}_i,\lambda_i) \\
=&A_0\bar{u}(p_3,\lambda_3)(\bar{\not{P}}+M_0)(-\gamma_5)C\bar{u}^T(p_2,\lambda_2) \\
&\times \bar{u}(p_1,\lambda_1)u(\bar{P},S_z)\Phi(x_i,k_{i\perp}),
\end{aligned}
$$

$$
\begin{aligned}
&\Psi_1^{S=\frac{1}{2},S_z}(\tilde{p}_i,\lambda_i) \\
=&A_1\bar{u}(p_3,\lambda_3)(\bar{\not{P}}+M_0)(\gamma^\mu-v^\mu)C\bar{u}^T(p_2,\lambda_2) \\
&\times \bar{u}(p_1,\lambda_1)(\frac{1}{\sqrt{3}}\gamma_\mu\gamma_5)u(\bar{P},S_z)\Phi(x_i,k_{i\perp}),
\end{aligned}
$$

Wavefunction of heavy baryon

$\bar{3}$

$$\Psi_0^{S=\frac{1}{2},S_z}(\tilde{p}_i,\lambda_i) \\ =A_0\bar{u}(p_3,\lambda_3)(\bar{\not{P}}+M_0)(-\gamma_5)C\bar{u}^T(p_2,\lambda_2) \\ \times\bar{u}(p_1,\lambda_1)u(\bar{P},S_z)\Phi(x_i,k_{i\perp}),$$

$$\left\langle\frac{1}{2}\frac{1}{2};s_3s_2\middle|0s_{23}\right\rangle\left\langle\frac{1}{2}0;s_10\middle|\frac{1}{2}S_z\right\rangle \\ =A_0\bar{u}(p_3,s_3)(\bar{\not{P}}+M_0)(-\gamma_5)C\bar{u}^T(p_2,s_2) \\ \times\bar{u}(p_1,s_1)u(\bar{P},S_z)$$

6

$$\Psi_1^{S=\frac{1}{2},S_z}(\tilde{p}_i,\lambda_i) \\ =A_1\bar{u}(p_3,\lambda_3)(\bar{\not{P}}+M_0)(\gamma^\mu-v^\mu)C\bar{u}^T(p_2,\lambda_2) \\ \times\bar{u}(p_1,\lambda_1)(\frac{1}{\sqrt{3}}\gamma_\mu\gamma_5)u(\bar{P},S_z)\Phi(x_i,k_{i\perp}),$$

$$\left\langle\frac{1}{2}\frac{1}{2};s_3s_2\middle|1s_{23}\right\rangle\left\langle\frac{1}{2}1;s_1s_{23}\middle|\frac{1}{2}S_z\right\rangle \\ =A_1\bar{u}(p_3,s_3)(\bar{\not{P}}+M_0)(\gamma^\mu-v^\mu)C\bar{u}^T(p_2,s_2) \\ \times\bar{u}(p_1,s_1)\left(\frac{1}{\sqrt{3}}\gamma_\mu\gamma_5\right)u(\bar{P},S_z)$$

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Wavefunction of light baryon

$$3 \otimes 3 \otimes 3 = (6_S \oplus \bar{3}_A) \otimes 3 = (10_S \oplus 8_{M_S}) \oplus (8_{M_A} \oplus 1_A)$$

8_{M_S} :

$$p : \frac{1}{\sqrt{6}}(2uud - udu - duu)$$
$$n : \frac{1}{\sqrt{6}}(-2ddu + dud + udd)$$
$$\Sigma^+ : \frac{1}{\sqrt{6}}(2uus - usu - suu)$$
$$\Sigma^o : \frac{1}{\sqrt{12}}(2uds - usd - dsu + 2dus - sud - s$$
$$\Sigma^- : \frac{1}{\sqrt{6}}(2dds - dsd - sdd)$$
$$\Lambda^o : \frac{1}{2}(usd + sud - sdu - dsu)$$
$$\Xi^o : \frac{1}{\sqrt{6}}(sus + uss - 2ssu)$$
$$\Xi^- : \frac{1}{\sqrt{6}}(sds + dss - 2ssd)$$

8_{M_A} :

$$p : \frac{1}{\sqrt{2}}(udu - duu)$$
$$n : \frac{1}{\sqrt{2}}(udd + dud)$$
$$\Sigma^+ : \frac{1}{\sqrt{2}}(usu - suu)$$
$$\Sigma^o : \frac{1}{2}(usd + dsu - sdu - sud)$$
$$\Sigma^- : \frac{1}{\sqrt{2}}(dsd - sdd)$$
$$\Lambda^o : \frac{1}{\sqrt{12}}(2uds - dsu - sud - 2dus - sdu + usd)$$
$$\Xi^o : \frac{1}{\sqrt{2}}(uss - sus)$$
$$\Xi^- : \frac{1}{\sqrt{2}}(dss - sds)$$

Wavefunction of light baryon

$$2 \otimes 2 \otimes 2 \;=\; (2 \otimes 2) \otimes 2 = (1 \oplus 3) \otimes 2 = (1 \otimes 2) \oplus (3 \otimes 2) = 2 \oplus 2 \oplus 4.$$

$$2_{M_S}: \quad |1/2, 1/2\rangle : \quad \frac{1}{\sqrt{6}}(2\uparrow\uparrow\downarrow - \uparrow\downarrow\uparrow - \downarrow\uparrow\uparrow)$$

$$|1/2, -1/2\rangle : \quad \frac{1}{\sqrt{6}}(\uparrow\downarrow\downarrow + \downarrow\uparrow\downarrow - 2\downarrow\downarrow\uparrow)$$

$$2_{M_A}: \quad |1/2, 1/2\rangle : \quad \frac{1}{\sqrt{2}}(\uparrow\downarrow\uparrow - \downarrow\uparrow\uparrow)$$

$$|1/2, -1/2\rangle : \quad \frac{1}{\sqrt{2}}(\uparrow\downarrow\downarrow - \downarrow\uparrow\downarrow)$$

Flavor symmetry wavefunction.

$$\frac{1}{\sqrt{2}}\left(\psi^f_{M_S}\eta^s_{M_S} + \psi^f_{M_A}\eta^s_{M_A}\right)$$

$$\begin{aligned}|\mathcal{B}(P,S,S_z)\rangle \;=&\; \int \{d^3\tilde{p}_1\}\{d^3\tilde{p}_2\}\{d^3\tilde{p}_3\} 2(2\pi)^3 \delta^3(\tilde{P} - \tilde{p}_1 - \tilde{p}_2 - \tilde{p}_3)\frac{1}{\sqrt{P^+}} \\ &\times \sum_{\lambda_1,\lambda_2,\lambda_3} \Psi^{S,S_z}(\tilde{p}_1,\tilde{p}_2,\tilde{p}_3,\lambda_1,\lambda_2,\lambda_3) C^{ijk} |q_1^i(p_1,\lambda_1) q_2^j(p_2,\lambda_2) q_3^k(p_3,\lambda_3)\rangle.\end{aligned}$$

Spin Wavefunction

$$\Psi^{S,S_z}_{S/A} = \bar{u}(p_3,\lambda_3)_\alpha \bar{u}^T(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \Gamma^{\alpha\beta\gamma}_{S/A} A_1 \Phi(x_i,k_{i\perp}),$$

Spin information

$$\boxed{\Gamma^{\alpha\beta\gamma}_S} = -[(\bar{P\!\!\!/} + M_0)(\gamma^\mu - v^\mu)C]^{\alpha\beta}\left[\frac{1}{\sqrt{3}}\gamma_\mu\gamma_5 u(\bar{P},S_z)\right]^\gamma, \qquad 2_{MS}$$

$$\boxed{\Gamma^{\alpha\beta\gamma}_A} = [(\bar{P\!\!\!/} + M_0)(-\gamma_5)C]^{\alpha\beta}[u(\bar{P},S_z)]^\gamma, \qquad 2_{MA}$$

Flavor Spin

$$\Psi^{S,S_z} = \frac{1}{\sqrt{2}}A_1\Phi(x_i,k_{i\perp})(\boxed{M^S_{\alpha\beta\gamma}}\boxed{\Gamma^{\alpha\beta\gamma}_S} + M^A_{\alpha\beta\gamma}\Gamma^{\alpha\beta\gamma}_A),$$

$$M^S_{\alpha\beta\gamma} = \frac{1}{\sqrt{6}}\Big(2\bar{u}(p_3,\lambda_3)_\alpha\bar{u}(p_2,\lambda_2)_\beta\bar{d}(p_1,\lambda_1)_\gamma - \bar{u}(p_3,\lambda_3)_\alpha\bar{d}(p_2,\lambda_2)_\beta\bar{u}(p_1,\lambda_1)_\gamma - \bar{d}(p_3,\lambda_3)_\alpha\bar{u}(p_2,\lambda_2)_\beta\bar{u}(p_1,\lambda_1)_\gamma\Big),$$

$$M^A_{\alpha\beta\gamma} = \frac{1}{\sqrt{2}}\Big(\bar{u}(p_3,\lambda_3)_\alpha\bar{d}(p_2,\lambda_2)_\beta\bar{u}(p_1,\lambda_1)_\gamma - \bar{d}(p_3,\lambda_3)_\alpha\bar{u}(p_2,\lambda_2)_\beta\bar{u}(p_1,\lambda_1)_\gamma\Big),$$

Flavor Wavefunction

One can define p_i as the momentum of a quark with a specified flavor

$$p_3 \longrightarrow \mathrm{u}$$
$$p_2 \longrightarrow \mathrm{u}$$
$$p_1 \longrightarrow \mathrm{d}$$

$$\begin{aligned}|\mathcal{B}(P,S,S_z)\rangle \;=\; &\int \{d^3\tilde{p}_1\}\{d^3\tilde{p}_2\}\{d^3\tilde{p}_3\} \times 2(2\pi)^3\delta^3(\tilde{P}-\tilde{p}_1-\tilde{p}_2-\tilde{p}_3)\frac{1}{\sqrt{P^+}} \\ &\times \sum_{\lambda_1,\lambda_2,\lambda_3} \Psi^{S,S_z}(\tilde{p}_1,\tilde{p}_2,\tilde{p}_3,\lambda_1,\lambda_2,\lambda_3)C^{ijk}|u^i(p_3,\lambda_1)u^j(p_2,\lambda_2)d^k(p_1,\lambda_3)\rangle.\end{aligned}$$

$$\Psi^{S,S_z} = \frac{1}{\sqrt{2}}A_1\Phi(x_i,k_{i\perp})\bar{u}(p_3,\lambda_3)_\alpha\bar{u}(p_2,\lambda_2)_\beta\bar{u}(p_1,\lambda_1)_\gamma \times \left(\frac{1}{\sqrt{6}}(2\Gamma_S^{\alpha\beta\gamma}-\Gamma_S^{\alpha\gamma\beta}-\Gamma_S^{\beta\gamma\alpha})+\frac{1}{\sqrt{2}}(\Gamma_A^{\alpha\gamma\beta}-\Gamma_A^{\gamma\beta\alpha})\right).$$

Light-front quark model in the hyperon

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Simplify the wavefunction

$$\Psi^{S,S_z} = \frac{1}{\sqrt{2}} A_1 \Phi(x_i, k_{i\perp}) \bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \times \left(\frac{1}{\sqrt{6}} (2\Gamma_S^{\alpha\beta\gamma} - \Gamma_S^{\alpha\gamma\beta} - \Gamma_S^{\beta\gamma\alpha}) + \frac{1}{\sqrt{2}} (\Gamma_A^{\alpha\gamma\beta} - \Gamma_A^{\gamma\beta\alpha}) \right).$$

Fierz transformation

$$\begin{aligned}
\Gamma_S^{\alpha\gamma\beta} &= -\frac{1}{4\sqrt{3}} \Big(\frac{1}{2} [(\not{\bar{P}} + M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta} [\sigma_{\mu\nu} u(\bar{P}, S_z)]^\gamma - [(\not{\bar{P}} + M_0)(\gamma^\mu - v^\mu) C]^{\alpha\beta} [\gamma_\mu \gamma_5 u(\bar{P}, S_z)]^\gamma \\
&\quad + 7[(\not{\bar{P}} + M_0)\gamma_5 C]^{\alpha\beta} [u(\bar{P}, S_z)]^\gamma - [(\not{\bar{P}} + M_0)\gamma^\mu\gamma_5 C]^{\alpha\beta} [\gamma_\mu u(\bar{P}, S_z)]^\gamma \Big) \\
\Gamma_S^{\beta\gamma\alpha} &= -\frac{1}{4\sqrt{3}} \Big(\frac{1}{2} [(\not{\bar{P}} + M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta} [\sigma_{\mu\nu} u(\bar{P}, S_z)]^\gamma - [(\not{\bar{P}} + M_0)(\gamma^\mu - v^\mu) C]^{\alpha\beta} [\gamma_\mu \gamma_5 u(\bar{P}, S_z)]^\gamma \\
&\quad - [(\not{\bar{P}} + M_0)\gamma^\mu\gamma_5 C]^{\alpha\beta} [\gamma_\mu u(\bar{P}, S_z)]^\gamma - [5(\not{\bar{P}} + M_0)\gamma_5 C]^{\alpha\beta} [u(\bar{P}, S_z)]^\gamma \Big) \\
\Gamma_A^{\alpha\gamma\beta} &= \frac{-1}{4} \Big(-\frac{1}{2} [(\not{\bar{P}} + M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta} [\sigma_{\mu\nu} u(\bar{P}, S_z)]^\gamma + [(\not{\bar{P}} + M_0)(\gamma^\mu + v^\mu)\gamma_5 C]^{\alpha\beta} [\gamma_\mu u(\bar{P}, S_z)]^\gamma \\
&\quad + [(\not{\bar{P}} + M_0)(\gamma^\mu - v^\mu) C]^{\alpha\beta} [\gamma_\mu \gamma_5 u(\bar{P}, S_z)]^\gamma \Big) \\
\Gamma_A^{\beta\gamma\alpha} &= \frac{1}{4} \Big(\frac{1}{2} [(\not{\bar{P}} + M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta} [\sigma_{\mu\nu} u(\bar{P}, S_z)]^\gamma - [(\not{\bar{P}} + M_0)(\gamma^\mu - v^\mu) C]^{\alpha\beta} [\gamma_\mu \gamma_5 u(\bar{P}, S_z)]^\gamma \\
&\quad - [(\not{\bar{P}} + M_0)\gamma^\mu\gamma_5 C]^{\alpha\beta} [\gamma_\mu u(\bar{P}, S_z)]^\gamma + [3(\not{\bar{P}} + M_0)\gamma_5 C]^{\alpha\beta} [u(\bar{P}, S_z)]^\gamma \Big)
\end{aligned}$$

The wavefunction of octet baryon

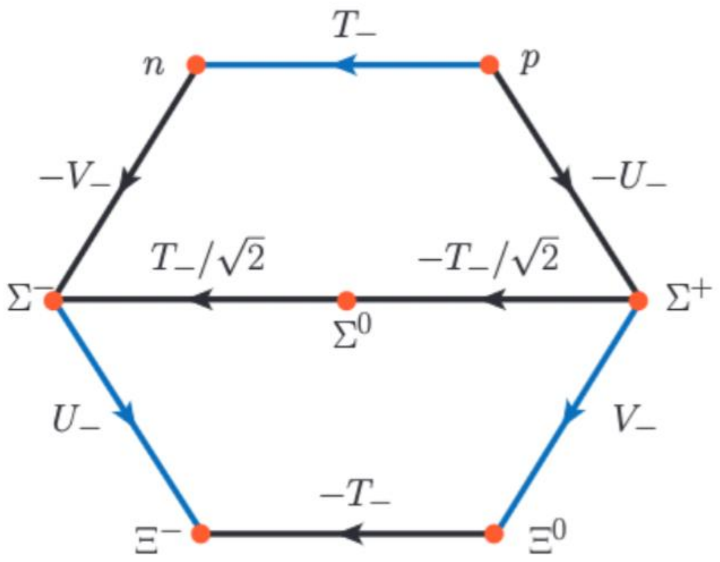
$$\Psi_p^{S,S_z} = \bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \Gamma_p^{\alpha\beta\gamma} A_p \Phi(x_i,k_{i\perp})$$

$$\Gamma_p^{\alpha\beta\gamma} = \Big([(\bar{\not P}+M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta}[\sigma_{\mu\nu}u(\bar{P},S_z)]^\gamma - 4[(\bar{\not P}+M_0)(\gamma^\mu - v^\mu)C]^{\alpha\beta}[\gamma_\mu\gamma_5 u(\bar{P},S_z)]^\gamma$$
$$-2[(\bar{\not P}+M_0)(\gamma^\mu - v^\mu)\gamma_5 C]^{\alpha\beta}[\gamma_\mu u(\bar{P},S_z)]^\gamma \Big).$$

the lowering operators

$$T\_u = d, \quad U\_d = s, \quad V\_u = s.$$

$$T_-|p\rangle = |n\rangle,\ -U_-|p\rangle = |\Sigma^+\rangle,\ \frac{1}{\sqrt{2}}T\_U\_|p\rangle = |\Sigma^0\rangle \frac{1}{2}T\_T\_U\_|p\rangle = |\Sigma^-\rangle,$$
$$-V\_U\_|p\rangle = |\Xi^0\rangle, T\_V\_U\_|p\rangle = |\Xi^-\rangle,\ \frac{-1}{\sqrt{6}}(V_- + U\_T_-)|p\rangle = |\Lambda\rangle.$$



The wavefunction of octet baryon

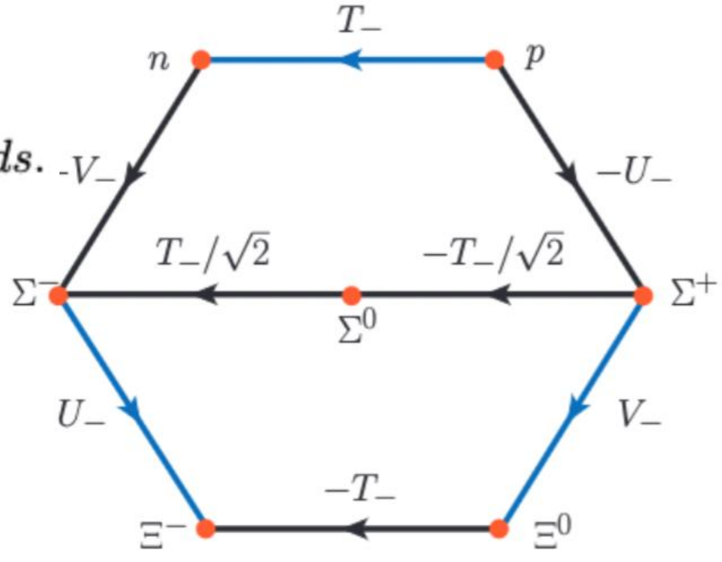
$$
\begin{aligned}
|\mathcal{B}(P,S,S_z)\rangle \; &= \int \{d^3\tilde{p}_1\}\{d^3\tilde{p}_2\}\{d^3\tilde{p}_3\} 2(2\pi)^3 \delta^3(\tilde{P}-\tilde{p}_1-\tilde{p}_2-\tilde{p}_3)\frac{1}{\sqrt{P^+}} \\
&\times \sum_{\lambda_1,\lambda_2,\lambda_3} \Psi^{SS_z}(\tilde{p}_1,\tilde{p}_2,\tilde{p}_3,\lambda_1,\lambda_2,\lambda_3) C^{ijk} |q_1^i(p_1,\lambda_1) q_2^j(p_2,\lambda_2) q_3^k(p_3,\lambda_3)\rangle,
\end{aligned}
$$

Order of q1 q2 q3

$$p: uud, \quad n: ddu, \quad \Sigma^+: uus, \quad \Sigma^0: uds, \Sigma^-: dds, \quad \Xi^0: ssu, \quad \Xi^-: ssd, \quad \Lambda: uds.$$

$$\Gamma_N^{\alpha\beta\gamma} \equiv \Gamma_p^{\alpha\beta\gamma} = -\Gamma_n^{\alpha\beta\gamma}, \; \Gamma_\Sigma^{\alpha\beta\gamma} \equiv \Gamma_{\Sigma^-}^{\alpha\beta\gamma} = \sqrt{2}\Gamma_{\Sigma^0}^{\alpha\beta\gamma} = -\Gamma_{\Sigma^+}^{\alpha\beta\gamma}, \; \Gamma_\Xi^{\alpha\beta\gamma} \equiv \Gamma_{\Xi^0}^{\alpha\beta\gamma} = -\Gamma_{\Xi^-}^{\alpha\beta\gamma}$$

$$\Gamma_N^{\alpha\beta\gamma} = \Gamma_\Sigma^{\alpha\beta\gamma} = \Gamma_\Xi^{\alpha\beta\gamma}.$$



The wavefunction of Lambda

$$\bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \Gamma_\Lambda^{\alpha\beta\gamma} A_\Lambda \Phi(x_i,k_{i\perp}),$$

$$\Gamma_\Lambda^{\alpha\beta\gamma} \; = \; [(\bar{\not{P}}+M_0)\gamma_5 C]^{\alpha\beta}[u(\bar{P},S_z)]^\gamma.$$

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The symmetry of three quark

$$\Psi_p^{S,S_z} = \bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \Gamma_p^{\alpha\beta\gamma} A_p \Phi(x_i,k_{i\perp})$$

$$\Gamma_p^{\alpha\beta\gamma} = \Big([(\bar{\not{P}}+M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta}[\sigma_{\mu\nu}u(\bar{P},S_z)]^\gamma - 4[(\bar{\not{P}}+M_0)(\gamma^\mu - v^\mu)C]^{\alpha\beta}[\gamma_\mu\gamma_5 u(\bar{P},S_z)]^\gamma$$
$$-2[(\bar{\not{P}}+M_0)(\gamma^\mu - v^\mu)\gamma_5 C]^{\alpha\beta}[\gamma_\mu u(\bar{P},S_z)]^\gamma\Big).$$

Fierz transformation

$$[(\bar{\not{P}}+M_0)(\gamma^\mu - v^\mu)C]^{\beta\alpha}[\gamma_\mu\gamma_5 u(\bar{P},S_z)]^\gamma = [(\bar{\not{P}}+M_0)(\gamma^\mu - v^\mu)C]^{\alpha\beta}[\gamma_\mu\gamma_5 u(\bar{P},S_z)]^\gamma,$$
$$[(\bar{\not{P}}+M_0)(\gamma^\mu - v^\mu)\gamma_5 C]^{\beta\alpha}[\gamma_\mu u(\bar{P},S_z)]^\gamma = [(\bar{\not{P}}-M_0)\gamma_5 C]^{\alpha\beta}[u(\bar{P},S_z)]^\gamma + [(\bar{\not{P}}-M_0)\gamma^\mu\gamma_5 C]^{\alpha\beta}[\gamma_\mu u(\bar{P},S_z)]^\gamma,$$
$$[(\bar{\not{P}}+M_0)\sigma^{\mu\nu}\gamma_5 C]^{\beta\alpha}[\sigma_{\mu\nu}u(\bar{P},S_z)]^\gamma = [(\bar{\not{P}}+M_0)\sigma^{\mu\nu}\gamma_5 C]^{\alpha\beta}[\sigma_{\mu\nu}u(\bar{P},S_z)]^\gamma - 4[M_0\gamma^\mu\gamma_5 C]^{\alpha\beta}[\gamma_\mu u(\bar{P},S_z)]^\gamma$$
$$+4[\bar{\not{P}}\gamma_5 C]^{\alpha\beta}[u(\bar{P},S_z)]^\gamma. \qquad \text{(A3)}$$

$$\Gamma_p^{\alpha\beta\gamma} = \Gamma_p^{\beta\alpha\gamma}$$

$$\Psi^{S,S_z} = \frac{1}{\sqrt{2}} A_1 \Phi(x_i,k_{i\perp}) \bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \times \left(\frac{1}{\sqrt{6}}(2\Gamma_S^{\alpha\beta\gamma} - \Gamma_S^{\alpha\gamma\beta} - \Gamma_S^{\beta\gamma\alpha}) + \frac{1}{\sqrt{2}}(\Gamma_A^{\alpha\gamma\beta} + \Gamma_A^{\beta\gamma\alpha})\right).$$

This symmetry can only be constructed based on the fact that the spin wave function in our work is symmetric under the exchange of λ1 and λ2

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The symmetry of three quark

$$\Psi^{S,S_z} = \frac{1}{\sqrt{2}} A_1 \Phi(x_i, k_{i\perp}) \bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \times \left(\frac{1}{\sqrt{6}}(2\Gamma_S^{\alpha\beta\gamma} - \Gamma_S^{\alpha\gamma\beta} - \Gamma_S^{\beta\gamma\alpha}) + \frac{1}{\sqrt{2}}(\Gamma_A^{\alpha\gamma\beta} + \Gamma_A^{\beta\gamma\alpha}) \right).$$

$$G_{S/A}(p_i,\lambda_i) = \bar{u}(p_3,\lambda_3)_\alpha \bar{u}(p_2,\lambda_2)_\beta \bar{u}(p_1,\lambda_1)_\gamma \times \Gamma_{S/A}^{\alpha\beta\gamma},$$

$$G_A(p_i,\lambda_i) = A(\bar{u}(p_3,\lambda_3), \bar{u}(p_2,\lambda_2), \bar{u}(p_1,\lambda_1)) \left\langle \frac{1}{2}\frac{1}{2};\lambda_3\lambda_2|0\lambda_{23} \right\rangle \left\langle 0\frac{1}{2};0\lambda_1|\frac{1}{2}S_z \right\rangle,$$

$$G_S(p_i,\lambda_i) = A(\bar{u}(p_3,\lambda_3), \bar{u}(p_2,\lambda_2), \bar{u}(p_1,\lambda_1)) \left\langle \frac{1}{2}\frac{1}{2};\lambda_3\lambda_2|1\lambda_{23} \right\rangle \left\langle 1\frac{1}{2};1\lambda_1|\frac{1}{2}S_z \right\rangle,$$

summing up all the helicities

$$\sum_{\lambda_1,\lambda_2,\lambda_3} G_A(p_i,\lambda_i) = \frac{1}{\sqrt{2}}\left[A\left(\bar{u}(p_3,\frac{1}{2}), \bar{u}(p_2,-\frac{1}{2}), \bar{u}(p_1,\frac{1}{2})\right) - A\left(\bar{u}(p_3,-\frac{1}{2}), \bar{u}(p_2,\frac{1}{2}), \bar{u}(p_1,\frac{1}{2})\right) \right],$$

$$\sum_{\lambda_1,\lambda_2,\lambda_3} G_S(p_i,\lambda_i) = \frac{1}{\sqrt{6}}\left[2A\left(\bar{u}(p_3,\frac{1}{2}), \bar{u}(p_2,\frac{1}{2}), \bar{u}(p_1,-\frac{1}{2})\right) - A\left(\bar{u}(p_3,\frac{1}{2}), \bar{u}(p_2,-\frac{1}{2}), \bar{u}(p_1,\frac{1}{2})\right) \right.$$
$$\left. -A(\bar{u}(p_3,-\frac{1}{2}), \bar{u}(p_2,\frac{1}{2}), \bar{u}(p_1,\frac{1}{2})) \right].$$

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The symmetry of three quark

$$
\begin{aligned}
\sum_{\lambda_1,\lambda_2,\lambda_3}\Psi^{S,S_z} = {} & A_1\Phi(x_i,k_{i\perp})\frac{1}{\sqrt{18}}\Big[2A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,-\tfrac{1}{2})\right)-A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,-\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)\\
& -A\left(\bar{u}(p_3,-\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)-A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,-\tfrac{1}{2})\right)\\
& +2A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,-\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)-A\left(\bar{u}(p_3,-\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)\\
& -A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,-\tfrac{1}{2})\right)+2A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,-\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)\\
& -A\left(\bar{u}(p_3,-\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)\Big]\\
= {} & \frac{1}{\sqrt{18}}A_1\Phi(x_i,k_{i\perp})\Big[2A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,-\tfrac{1}{2})\right)-A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,-\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)\\
& -A\left(\bar{u}(p_3,-\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right)+\text{permutations}\Big].
\end{aligned}
$$

The symmetry of three quark

$$
\sum_{\lambda_1,\lambda_2,\lambda_3} \Psi^{S,S_z} = \frac{1}{\sqrt{18}} A_1 \boxed{\Phi(x_i,k_{i\perp})} \Bigg[2A\left(\bar{u}(p_3,\frac{1}{2}),\bar{u}(p_2,\frac{1}{2}),\bar{u}(p_1,-\frac{1}{2})\right) - A\left(\bar{u}(p_3,\frac{1}{2}),\bar{u}(p_2,-\frac{1}{2}),\bar{u}(p_1,\frac{1}{2})\right) - A\left(\bar{u}(p_3,-\frac{1}{2}),\bar{u}(p_2,\frac{1}{2}),\bar{u}(p_1,\frac{1}{2})\right) + \text{permutations} \Bigg].
$$

$$
\Phi(x_i,k_{i\perp}) = \sqrt{\frac{e_1 e_2 e_3}{x_1 x_2 x_3 M_0}} 16 \left(\frac{\pi}{\beta^2}\right)^{3/2} \pi^{-3/16} \times \exp\left[-\sum_{i\le j}^{3} \frac{\vec{k}_{i\perp}\cdot\vec{k}_{j\perp} + k_{iz}k_{jz}}{2\beta^2} \right]
$$

$$
\int \left(\prod_{i=1}^{3} \frac{dx_i d^2 k_{i\perp}}{2(2\pi)^3} \right) 2(2\pi)^3 |\Phi(x_i,k_{i\perp})|^2 \times \delta\left(1-\sum x_i\right) \delta^2\left(\sum k_{i\perp}\right) = 1.
$$

The shape parameter can be determined by the decay constent which estimated by Lattice QCD

$$
\begin{aligned}
\lambda_1^{B\neq\Lambda} = & \frac{1}{4m_B^2} \int \frac{dx_2 d^2\vec{k}_{2\perp}}{2(2\pi)^3} \frac{dx_3 d^2\vec{k}_{3\perp}}{2(2\pi)^3} \frac{1}{\sqrt{x_1 x_2 x_3}} A_{B\neq\Lambda} \Phi(x_i,k_{i\perp}) \\
& \times \Big(-2\mathrm{Tr}[(\bar{\not{P}}+M_0)(\gamma^\alpha - v^\alpha)\gamma_5(\not{p}_2 - m_2)(1-\gamma_5)\gamma^\mu(\not{p}_3+m_3)]\mathrm{Tr}[\gamma_\mu(1+\gamma_5)(\not{p}_1+m_1)\gamma_\alpha(\bar{\not{P}}+M_0)] \\
& -4\mathrm{Tr}[(\bar{\not{P}}+M_0)(\gamma^\alpha - v^\alpha)(\not{p}_2 - m_2)(1-\gamma_5)\gamma^\mu(\not{p}_3+m_3)]\mathrm{Tr}[\gamma_\mu(1+\gamma_5)(\not{p}_1+m_1)\gamma_\alpha\gamma_5(\bar{\not{P}}+M_0)] \\
& +\mathrm{Tr}[(\bar{\not{P}}+M_0)\sigma^{\alpha\beta}\gamma_5(\not{p}_2 - m_2)(1-\gamma_5)\gamma^\mu(\not{p}_3+m_3)]\mathrm{Tr}[\gamma_\mu(1+\gamma_5)(\not{p}_1+m_1)\sigma_{\alpha\beta}(\bar{\not{P}}+M_0)] \Big),
\end{aligned}
$$

$$
\begin{aligned}
\lambda_1^{\Lambda} = & -\frac{1}{4m_\Lambda^2} \int \frac{dx_2 d^2\vec{k}_{2\perp}}{2(2\pi)^3} \frac{dx_3 d^2\vec{k}_{3\perp}}{2(2\pi)^3} \frac{\sqrt{6}}{\sqrt{x_1 x_2 x_3}} A_\Lambda \Phi(x_i,k_{i\perp}) \\
& \times \Big(\mathrm{Tr}[(\bar{\not{P}}+M_0)\gamma_5(\not{p}_2 - m_d)(1-\gamma_5)\gamma^\mu(\not{p}_3+m_u)]\mathrm{Tr}[\gamma_\mu(1+\gamma_5)(\not{p}_1+m_s)(\bar{\not{P}}+M_0)] \Big).
\end{aligned}
$$

Light-front quark model in the hyperon

The symmetry of three quark

$$\sum_{\lambda_1,\lambda_2,\lambda_3} \Psi^{S,S_z} = \frac{1}{\sqrt{18}} A_1 \boxed{\Phi(x_i,k_{i\perp})} \Big[2A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,-\tfrac{1}{2})\right) - A\left(\bar{u}(p_3,\tfrac{1}{2}),\bar{u}(p_2,-\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right) - A\left(\bar{u}(p_3,-\tfrac{1}{2}),\bar{u}(p_2,\tfrac{1}{2}),\bar{u}(p_1,\tfrac{1}{2})\right) + \text{permutations}\Big].$$

$$\Phi(x_i,k_{i\perp}) = \sqrt{\frac{e_1e_2e_3}{x_1x_2x_3M_0}} 16\left(\frac{\pi}{\beta^2}\right)^{3/2} \pi^{-3/16} \times \exp\left[-\sum_{i\le j}^{3} \frac{\vec{k}_{i\perp}\cdot\vec{k}_{j\perp} + k_{iz}k_{jz}}{2\beta^2}\right]$$

$$\int \left(\prod_{i=1}^{3} \frac{dx_i d^2k_{i\perp}}{2(2\pi)^3}\right) 2(2\pi)^3 |\Phi(x_i,k_{i\perp})|^2 \times \delta\left(1-\sum x_i\right)\delta^2\left(\sum k_{i\perp}\right) = 1.$$

The shape parameter can be determined by the decay constent which estimated by Lattice QCD

baryons	N	Σ	Ξ	Λ
$\lambda_1^B(10^{-3}\text{GeV}^2)$	-44.9	-46.1	-49.8	-42.2
$\beta(\text{GeV})$	0.361	0.345	0.434	0.378

Hamiltonians

$$\mathcal{H}(s \to d\gamma) = \frac{G_F}{\sqrt{2}} V_{us} V_{ud}^* \sum_i^{1-6,12} [(z_i(\mu) + \tau y_i(\mu)) Q_i(\mu)],$$

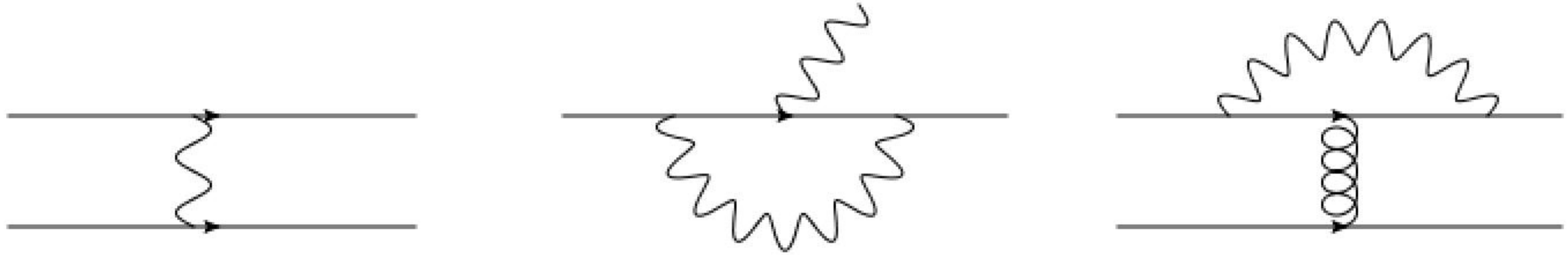
$$Q_1 = [\bar{u}_\alpha \gamma_\mu (1-\gamma_5) s_\beta][\bar{d}_\beta \gamma^\mu (1-\gamma_5) u_\alpha], \quad Q_2 = [\bar{u}_\alpha \gamma_\mu (1-\gamma_5) s_\alpha][\bar{d}_\beta \gamma^\mu (1-\gamma_5) u_\beta],$$

$$Q_3 = [\bar{d}_\alpha \gamma_\mu (1-\gamma_5) s_\alpha] \sum_q [\bar{q}_\beta \gamma^\mu (1-\gamma_5) q_\beta], \quad Q_4 = [\bar{d}_\alpha \gamma_\mu (1-\gamma_5) s_\beta] \sum_q [\bar{q}_\beta \gamma^\mu (1-\gamma_5) q_\alpha],$$

$$Q_5 = [\bar{d}_\alpha \gamma_\mu (1-\gamma_5) s_\alpha] \sum_q [\bar{q}_\beta \gamma^\mu (1+\gamma_5) q_\beta], \quad Q_6 = [\bar{d}_\alpha \gamma_\mu (1-\gamma_5) s_\beta] \sum_q [\bar{q}_\beta \gamma^\mu (1+\gamma_5) q_\alpha],$$

$$Q_{12} = \frac{e}{16\pi^2} m_s \bar{d} \sigma^{\mu\nu} (1+\gamma_5) s F_{\mu\nu}, \quad \tau = -\frac{V_{ts} V_{td}^*}{V_{us} V_{ud}^*},$$

$$z_1 = -0.606, \ z_2 = 1.346, \ y_1 = y_2 = 0, \ z_{12} = -0.081, \ y_{12} = -0.383.$$



omit

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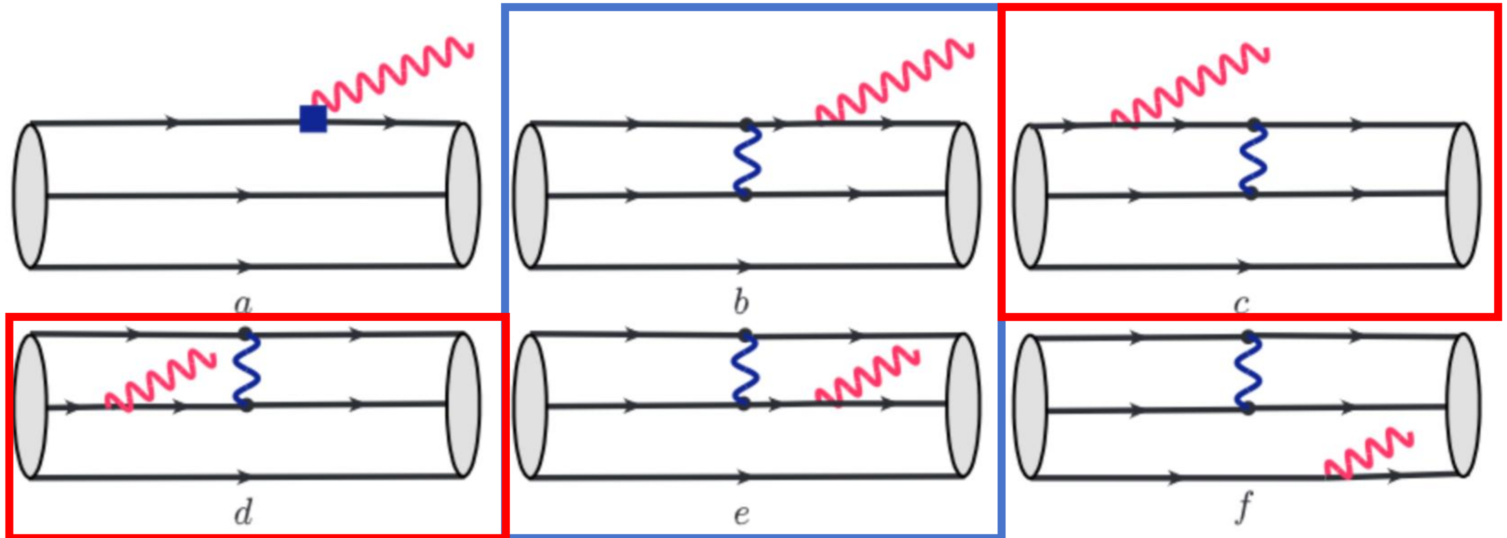
Matrix element

$$\langle B'\gamma|\mathcal{H}(0)|B\rangle = \frac{iG_F}{\sqrt{2}}\bar{u}_{B'}(a+b\gamma_5)\sigma_{\mu\nu}u_B\frac{q^\nu\epsilon^{*\mu}}{m_B},$$

$$\mathcal{M} \equiv \langle B'\gamma|\mathcal{H}(0)|B\rangle = \frac{G_F}{\sqrt{2}}(\mathcal{M}_P+\mathcal{M}_T),$$

$$\mathcal{M}_T = V_{us}V_{ud}^*\sum_i^{1,2}(z_i+\tau y_i)\langle B'\gamma|Q_i|B\rangle, \quad \mathcal{M}_P = V_{us}V_{ud}^*(z_{12}+\tau y_{12})\frac{e}{8\pi^2}m_s\times\langle B'\gamma|\bar{d}\sigma^{\mu\nu}(1+\gamma_5)sF_{\mu\nu}|B\rangle,$$



Matrix element

$$\mathcal{M} \equiv \langle B'\gamma|\mathcal{H}(0)|B\rangle = \frac{G_F}{\sqrt{2}}(\mathcal{M}_P + \mathcal{M}_T),$$

$$\mathcal{M}_T = V_{us}V_{ud}^*\sum_i (z_i + \tau y_i)\langle B'\gamma|Q_i|B\rangle, \quad \mathcal{M}_P = V_{us}V_{ud}^*(z_{12}+\tau y_{12})\frac{e}{8\pi^2}m_s \times \langle B'\gamma|\bar{d}\sigma^{\mu\nu}(1+\gamma_5)sF_{\mu\nu}|B\rangle,$$

$$\mathcal{M}_P = -V_{us}V_{ud}^*(z_{12}+\tau y_{12})\frac{e}{8\pi^2}m_s\Gamma_B^{abc}\overline{\Gamma}_{B'}^{\alpha\beta\gamma}\int\frac{dx_1 d^2\vec{k}_{1\perp}}{2(2\pi)^3}\frac{dx_2 d^2\vec{k}_{2\perp}}{2(2\pi)^3}\frac{\Phi(x_i,k_{i\perp})\Phi^*(x_i',k_{i\perp}')}{\sqrt{x_1(1-x_2'-x_3')}}$$
$$\times\ [(\not{p}_1' + m_1')\sigma^{\mu\nu}(1+\gamma_5)(\not{p}_1+m_1)]_{\gamma c}\times[\not{p}_3+m_3]_{\alpha a}[\not{p}_2+m_2]_{\beta b}A_B A_{B'}(2iq_\nu\epsilon_\mu^*(q)),$$

$$\mathcal{M}_T^b = C\int dx_1 dx_2 dx_1'\frac{d^2k_{1\perp}}{2(2\pi)^3}\frac{d^2k_{2\perp}}{2(2\pi)^3}\frac{d^2k_{1\perp}'}{2(2\pi)^3}\frac{A_B A_{B'}\epsilon_\mu^*(q)\Gamma_B^{def}\overline{\Gamma}_{B'}^{abc}\Phi(x_i,k_{i\perp})\Phi^*(x_i',k_{i\perp}')}{\sqrt{x_1(1-x_1-x_2)x_1'(1-x_1'-x_2)}(k^2-m_3'^2)}$$
$$\times\ [(\not{p}_3'+m_3')\gamma^\mu(\not{k}+m_3')\gamma_\nu(1-\gamma_5)(\not{p}_1+m_1)]_{af}\times[(\not{p}_1'+m_1')\gamma^\nu(1-\gamma_5)(\not{p}_3+m_3)]_{cd}[\not{p}_2+m_2]_{be},$$

$$\mathcal{M}_T^c = C\int dx_1 dx_2 dx_1'\frac{d^2k_{1\perp}}{2(2\pi)^3}\frac{d^2k_{2\perp}}{2(2\pi)^3}\frac{d^2k_{1\perp}'}{2(2\pi)^3}\frac{A_B A_{B'}\epsilon_\mu^*(q)\Gamma_B^{def}\overline{\Gamma}_{B'}^{abc}\Phi(x_i,k_{i\perp})\Phi^*(x_i',k_{i\perp}')}{\sqrt{x_1(1-x_1-x_2)x_1'(1-x_1'-x_2)}(k^2-m_1^2)}$$
$$\times\ [(\not{p}_3'+m_3')\gamma_\nu(1-\gamma_5)(\not{k}+m_1)\gamma^\mu(\not{p}_1+m_1)]_{af}\times[(\not{p}_1'+m_1')\gamma^\nu(1-\gamma_5)(\not{p}_3+m_3)]_{cd}[\not{p}_2+m_2]_{be},$$

$$\mathcal{M}_T^f = C\int dx_1 dx_1'\frac{d^2k_{1\perp}}{2(2\pi)^3}\frac{d^2k_{1\perp}'}{2(2\pi)^3}A_B A_{B'}\epsilon_\mu^*(q)\Gamma_B^{def}\overline{\Gamma}_{B'}^{abc}\frac{1}{\sqrt{x_1(1-x_1-x_2)x_1'(1-x_1'-x_2')}x_2P^+q^-}$$
$$\times\left(-\int dx_2\frac{d^2k_{2\perp}}{2(2\pi)^3}[(\not{p}_2-\not{q}+m_2)\gamma^\mu(\not{p}_2+m_2)]_{be}+\int dx_2'\frac{d^2k_{2\perp}'}{2(2\pi)^3}[(\not{p}_2'+m_2)\gamma^\mu(\not{p}_2'+\not{q}+m_2)]_{be}\right)$$
$$\times\ [(\not{p}_3'+m_3')\gamma_\nu(1-\gamma_5)(\not{p}_1+m_1)]_{af}\Phi(x_i,k_{i\perp})\times[(\not{p}_1'+m_1')\gamma^\nu(1-\gamma_5)(\not{p}_3+m_3)]_{cd}\Phi^*(x_i',k_{i\perp}'),$$

$$C = eV_{us}V_{ud}^*[z_1 - z_2 + \tau(y_1-y_2))],$$

Symmetry factor

For every specific radiative decay process, we need to consider an additional symmetry factor $SF^{T/P}_{B\to B'}$ arising from the flavor and color symmetries of each baryon in the penguin or tree diagram,

$$SF^{P}_{\Sigma^+\to p\gamma}=2,\qquad SF^{T}_{\Sigma^+\to p\gamma}=4,\qquad SF^{P}_{\Lambda/\Sigma^0\to n\gamma}=2,\qquad SF^{T}_{\Lambda/\Sigma^0\to n\gamma}=2$$

$$SF^{P}_{\Xi^0\to\Lambda/\Sigma^0\gamma}=2,\qquad SF^{T}_{\Xi^0\to\Lambda/\Sigma^0\gamma}=2,\qquad SF^{P}_{\Xi^-\to\Sigma^-\gamma}=4,\qquad SF^{T}_{\Xi^-\to\Sigma^-\gamma}=0.$$

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Numerical results

TABLE III. The corresponding form factor for each Feynman diagram in unit ($10^{-3}\mathrm{GeV}^2$). Here we show the numerical results for penguin diagram. Actually, a^P, b^P have complex phase from CKM matrix as $e^{i\delta}$ with $\delta = -3.14$. The total form factor can be expressed as $a = a^P e^{i\delta} + a^W$ and $b = b^P e^{i\delta} + b^W$.

form factors	a^P	a^b	a^c	a^d	a^e	a^f	b^P	b^b	b^c	b^d	b^e	b^f	a^W	b^W
$\Sigma^+ \to p\gamma$	0.73	−5.96	−4.77	6.75	−4.86	1.44	0.21	0.83	−0.43	−0.43	0.49	0.54	−7.40	1.00
$\Lambda \to n\gamma$	−0.31	−0.79	−1.58	3.97	−6.30	11.67	0.06	0.07	−0.75	−0.62	0.34	−0.92	6.97	−1.88
$\Sigma^0 \to n\gamma$	1.06	1.44	1.97	−2.09	−1.16	−1.68	0.30	−0.42	−0.10	−0.29	−0.64	2.36	−1.52	0.91
$\Xi^0 \to \Lambda\gamma$	−0.07	0.17	9.56	4.05	−2.05	−20.52	0.006	0.32	0.42	−0.20	−1.07	−1.62	−8.79	−2.15
$\Xi^0 \to \Sigma^0\gamma$	0.02	11.12	−27.56	10.49	−1.68	29.03	0.01	0.97	0.85	0.10	−0.10	−4.98	21.40	−3.16
$\Xi^- \to \Sigma^-\gamma$	−0.04	-	-	-	-	-	−0.01	-	-	-	-	-	-	-

The W exchange diagram give the mainly contribution.

We are working hard to recalculate the results

Phenomenological analysis

$$Br(B \to B'\gamma) = \frac{G_F^2}{16\pi\Gamma_B} m_B \left(1 - \frac{m_{B'}^2}{m_B^2}\right)^3 (|a|^2 + |b|^2), \quad \alpha = \frac{\Re(a \cdot b)}{|a|^2 + |b|^2}.$$

polarization

$$\frac{dBr^{\pm}(B \to B'\gamma)}{d\cos(\theta_\gamma)} = \frac{G_F^2}{16\pi\Gamma_B} m_B \left(1 - \frac{m_{B'}^2}{m_B^2}\right)^3 \times (|a|^2 + |b|^2 \mp 2Re(a \cdot b^*) \cos(\theta_\gamma)).$$

$$A_{FB}^{\pm} = \frac{\left(\int_0^1 d\cos\theta_\gamma \frac{dBr^{\pm}}{d\cos\theta_\gamma} - \int_{-1}^0 d\cos\theta_\gamma \frac{dBr^{\pm}}{d\cos\theta_\gamma}\right)}{Br^{\pm}}.$$

Phenomenological analysis

The disparity in α(Σ+ → pγ) indicates that these processes may entail a substantial strong phase

$$a = |a^P|e^{i\delta}e^{i\delta_a^P} + |a^W|e^{i\delta_a^W}, \quad b = |b^P|e^{i\delta}e^{i\delta_b^P} + |b^W|e^{i\delta_b^W}$$

The weak phase is determined by the CKM matrix element.
One can try to determine the strong phase by fit the α.

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Conclusion and outlook

- We explore the LFQM in a three-quark picture for the light baryon octetRich dynamics effect. CP violation, EDM and so on.
- Our calculations indicate that the main contribution to hyperon weak radiative decays induced by s → d comes from the W exchange Feynman diagram.
- We are working hard to recalculate the results
- We are trying decrease are error from the vegas integration and give an error analysis.
- We are trying to estimate the contibution of QCD penguin diagram.