current for nucleon: (uud) proton.

$$J(x) = 2\epsilon_{abc} \sum_{i=1}^{2} \left[q^{T}_{1a}(x)\, C A_1^i\, q_{2,b}(x) \right] A_2^i\, q^c_1(x) \qquad A_1^1 = I,\quad A_1^2 = A_2^1 = \gamma_5,\quad A_2^2 = t$$

$q_1 = u \quad q_2 = d$

$$J(x) = 2\epsilon_{abc}\left[(u_a^T(x)\, C\, d_b(x))\, \gamma_5\, u_c(x) + (u_a^T(x)\, C \gamma_5\, d_b(x))\, t\, u_c(x) \right]$$

$$J^\dagger(0) = 2\epsilon_{a'b'c'}\left[u^\dagger_{c'}(0)\, \underset{\gamma_5}{\gamma_5^\dagger}\, (d^\dagger_{b'}(0)\, C^\dagger\, u^{T\dagger}_{a'}(0)) + t\, u^\dagger_{c'}(0)\, (d^\dagger_{b'}(0)\, \underset{-\gamma_0\gamma_5^\dagger}{\gamma_5^\dagger}\, \underset{-\gamma_0 C \gamma_0}{C^\dagger}\, u^{T\dagger}_{a'}(0)) \right]$$

$$\bar{J} = J^\dagger(0)\gamma_0, \quad \bar{J}(0) = 2\epsilon_{a'b'c'}\left[-\underbrace{u^\dagger_{c'}(0)\gamma_0}_{\bar{u}_c}\gamma_5\, (\underbrace{d^\dagger_{b'}(0)\gamma_0}_{\bar{d}_{b'}}\, C\, \underbrace{\gamma_0^T\, u^{\dagger T}_{a'}(0)}_{\bar{u}^T_{a'}}) - t\, \underbrace{u^\dagger_{c'}\gamma_0}_{\bar{u}_{c'}}\, (\underbrace{d^\dagger_{b'}(0)\gamma_0}_{\bar{d}_{b'}}\, \gamma_5\, C\, \underbrace{\gamma_0^T\, u^{T\dagger}_{a'}(0)}_{\bar{u}^T_{a'}}) \right]$$

$$\bar{J} = +2\epsilon_{a'b'c'}\left[\bar{u}_{c'}(0)\gamma_5\, (\bar{d}_{b'}(0)\, C\, \bar{u}^T_{a'}(0)) - t\, \bar{u}_{c'}(0)\, (\bar{d}_{b'}(0)\gamma_5\, C\, \bar{u}^T_{a'}(0)) \right]$$

$$\Pi(p) = \int d^4x\, e^{ipx} \langle 0| T\{ J(x) \bar{J}(0) \} |0\rangle$$ [1501.05857.]

$$\Pi(p) = \int d^4x\, e^{ipx} \langle 0| T\Big\{ \epsilon_{abc} \Big[\big(u^T_{a\alpha}(x) C_{\alpha\beta} d_{b\beta}(x) \big) \gamma_{5\,\lambda\delta}\, u_{c\delta}(x) + \big(u^T_{a\alpha}(x) (C\gamma_5)_{\alpha\beta} d_{b\beta}(x) \big) t\, 1_{\lambda\delta}\, u_{c\delta}(x) \Big]$$

$$(-\epsilon_{a'b'c'}) \Big[\bar{u}_{c'\lambda'}(0)\, \gamma_{5\,\lambda'\delta'} \big(\bar{d}_{b'\alpha'}(0) C_{\alpha'\beta'} \bar{u}^T_{a'\beta'}(0) \big) + t\, \bar{u}_{c'\lambda'}(0)\, 1_{\lambda'\delta'} \big(\bar{d}_{b'\alpha'}(0) (\gamma_5 C)_{\alpha'\beta'} \bar{u}^T_{a'\beta'}(0) \big) \Big] \Big\}$$

$$\Pi(p) = \int d^4x\, e^{ipx} \langle 0| T\Big\{ -4\, \epsilon_{abc}\, \epsilon_{a'b'c'}$$

$$\big(u^T_{a\alpha}(x) C_{\alpha\beta} d_{b\beta}(x) \big) \gamma_{5\,\lambda\delta}\, u_{c\delta}(x)\, \bar{u}_{c'\lambda'}(0)\, \gamma_{5\,\lambda'\delta'} \big(\bar{d}_{b'\alpha'}(0) C_{\alpha'\beta'} \bar{u}^T_{a'\beta'}(0) \big)$$

$$+ \big(u^T_{a\alpha}(x) C_{\alpha\beta} d_{b\beta}(x) \big) \gamma_{5\,\lambda\delta}\, u_{c\delta}(x)\, t\, \bar{u}_{c'\lambda'}(0)\, 1_{\lambda'\delta'} \big(\bar{d}_{b'\alpha'}(0) (\gamma_5 C)_{\alpha'\beta'} \bar{u}^T_{a'\beta'}(0) \big)$$

$$+ \big(u^T_{a\alpha}(x) (C\gamma_5)_{\alpha\beta} d_{b\beta}(x) \big) t\, 1_{\lambda\delta}\, u_{c\delta}(x)\, \bar{u}_{c'\lambda'}(0)\, \gamma_{5\,\lambda'\delta'} \big(\bar{d}_{b'\alpha'}(0) C_{\alpha'\beta'} \bar{u}_{a'\beta'}(0) \big)$$

$$+ \big(u^T_{a\alpha}(x) (C\gamma_5)_{\alpha\beta} d_{b\beta}(x) \big) t\, 1_{\lambda\delta}\, u_{c\delta}(x)\, t\, \bar{u}_{c'\lambda'}(0)\, 1_{\lambda'\delta'} \big(\bar{d}_{b'\alpha'}(0) (\gamma_5 C)_{\alpha'\beta'} \bar{u}^T_{a'\beta'}(0) \big) |0\rangle \Big\}$$

(4) $(\gamma_5 C)^T = -\gamma_5 C$, $(C\gamma_5)^T = -C\gamma_5$, $\hat{U} = C \hat{U} C$, $\gamma_5^T = -C\gamma_5 C$,

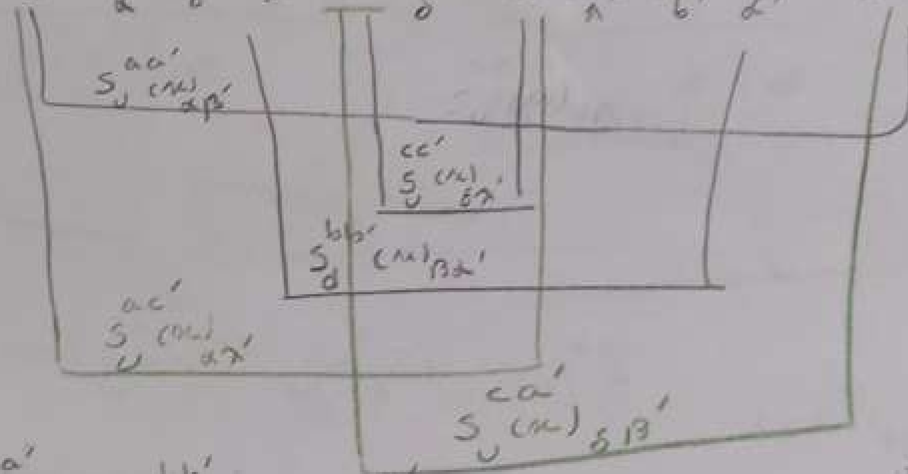
note : $\langle 0| \psi^{a}_{(x)} \bar{\psi}^{b}(y) |0\rangle = S^{ab}_{\psi}(x-y)$, $\tilde{S} = C S^{T} C$, $\gamma_5^{T} = -C\gamma_5 C$

$(C\gamma_5)^{T} = -C\gamma_5$, $(\gamma_5 C)^{T} = -\gamma_5 C$

Term ① :

$$-4\left(u^{T}_{a\,\alpha}(x)\, C_{\alpha\beta}\, d_{b\,\beta}(x)\right) (\gamma_5)_{\lambda\delta}\, u_{c\,\delta}(x)\, \bar{u}_{c'\,\lambda'}(0)\, (\gamma_5)_{\lambda'\delta'} \left(\bar{d}_{b'\,\alpha'}(0)\, C_{\alpha'\beta'}\, \bar{u}^{T}_{a'\,\beta'}(0)\right)$$

$$-4\, C_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda\delta}\, (\gamma_5)_{\lambda'\delta'}\;\; u^{T}_{a}(x)_{\alpha}\; d_{b}(x)_{\beta}\; u_{c}(x)_{\delta}\; \bar{u}_{c'}(0)_{\lambda'}\; \bar{d}_{b'}(0)_{\alpha'}\; \bar{u}^{T}_{a'}(0)_{\beta'}$$



sign of first eq. $\rightarrow +$

second eq. $\rightarrow -$

$\underline{1}$: $-4\, C_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda\delta}\, (\gamma_5)_{\lambda'\delta'}\; S^{aa'}_{u}(x)_{\alpha\beta'}\; S^{bb'}_{d}(x)_{\beta\alpha'}\; S^{cc'}_{u}(x)_{\delta\lambda'} \longrightarrow$

$\underline{2}$: $+4\, C_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda\delta}\, (\gamma_5)_{\lambda'\delta'}\; S^{bb'}_{d}(x)_{\beta\alpha'}\; S^{ac'}_{u}(x)_{\alpha\lambda'}\; S^{ca'}_{u}(x)_{\delta\beta'}$

Trace

④

Term 2

$$-4\Big(U^{Ta}(x)_\alpha\, C_{\alpha\beta}\, d_b(x)_\beta\, (\gamma_5)_{\lambda\delta}\, U_c(x)_\delta\; t\; \bar{U}^{c'}(0)_{\lambda'}\, \Gamma_{\lambda'\delta'}\, \bar{d}^{b'}(0)_{a'}\, (\gamma_5 C)_{\alpha'\beta'}\, \bar{U}^{Ta'}(0)_{\beta'} \Big)$$

$$4t\,(C\gamma_5)_{\alpha'\beta'}\, C_{\alpha\beta}\, (\gamma_5)_{\lambda\delta}\, \Gamma_{\lambda'\delta'}\, U^{Ta}(x)_\alpha\, d_b(x)_\beta\, U_c(x)_\delta\, \bar{U}^{c'}(0)_{\lambda'}\, \bar{d}^{b'}(0)_a\, \bar{U}^{Ta'}(0)_{\beta'}$$

$S_u^{aa'}(x)_{\alpha\beta'}$ $S_d^{bb'}(x)_{\beta\alpha}$ $S_u^{cc'}(x)_{\delta\lambda}$

$S_u^{ac'}(x)_{\alpha\lambda'}$ $S_u^{ca'}(x)_{\delta\beta'}$

زوجي +

فردي −

$$-4t\, C_{\alpha\beta}\, (\gamma_5 C)_{\alpha'\beta'}\, \Gamma_{\lambda'\delta'}\, (\gamma_5)_{\lambda\delta}\; S_u^{aa'}(x)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\alpha}\, S_u^{cc'}(x)_{\delta\lambda}$$

$$+4t\, C_{\alpha\beta}\, (\gamma_5 C)_{\alpha'\beta'}\, \Gamma_{\lambda'\delta'}\, (\gamma_5)_{\lambda\delta}\; S_u^{ac'}(x)_{\alpha\lambda'}\, S_u^{cc'}(x)_{\delta\lambda}\, S_u^{ca'}(x)_{\delta\beta'}$$

$\boxed{\text{Term 3}}$

$$-4\left(u^T_a(x)_\alpha \, (C\gamma_5)_{\alpha\beta} \, d_b(x)_\beta \; t \; 1_{\lambda\delta} \, u_c(x)_\delta \, \bar{u}_{c'}(0)_{\lambda'} \, (\gamma_5)_{\lambda'\delta'} \, \bar{d}_{b'}(0)_{\alpha'} \, C_{\alpha'\beta'} \, \bar{u}_{a'}(0)_{\beta'} \right)$$

$$-4t\,(C\gamma_5)_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda'\delta'}\, 1_{\lambda\delta}\, u^T_a(x)_\alpha\, d_b(x)_\beta\, u_c(x)_\delta\, \bar{u}_{c'}(0)_{\lambda'}\, \bar{d}_{b'}(0)_{\alpha'}\, \bar{u}_{a'}(0)_{\beta'}$$

$S^{aa'}_{\alpha\beta'}(x)$ $\quad U_d^{bb'}(x)_{\beta\alpha'}$ $\quad S_u^{cc'}(x)_{\delta\lambda'}$

$S_u^{ac'}(x)_{\alpha\lambda'}$ $\quad S_u^{c'a'}(x)_{\lambda'\beta'}$

$$-4t\,(C\gamma_5)_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda'\delta'}\, 1_{\lambda\delta}\, S^{aa'}_{\alpha\beta'}(x)\, U_d^{bb'}(x)_{\beta\alpha'}\, S_u^{cc'}(x)_{\delta\lambda'}$$

$$+4t\,(C\gamma_5)_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda'\delta'}\, 1_{\lambda\delta}\, S_u^{ac'}(x)_{\alpha\lambda'}\, S_d^{bb'}(x)_{\beta\lambda'}\, S_u^{c'a'}(x)_{\lambda'\beta'}$$

Term 4

$$-4t^2\, u^{Ta}_{\alpha}(x)\, (C\gamma_5)_{\alpha\beta}\, d^{b}_{\beta}(x)\, 1_{\lambda\delta}\, u^{c}_{\delta}(x)\, \bar{u}^{c'}_{\lambda'}(0)\, 1_{\lambda'\delta'}\, \bar{d}^{b'}_{\alpha'}(0)\, (\gamma_5 C)_{\alpha'\beta'}\, \bar{u}^{Ta'}_{\beta'}(0)$$

$$-4t^2\, (C\gamma_5)_{\alpha\beta}\, (\gamma C)_{\alpha'\beta'}\, 1_{\lambda\delta}\, 1_{\lambda'\delta'}\, u^{Ta}_{\alpha}(x)\, d^{b}_{\beta}(x)\, u^{c}_{\delta}(x)\, \bar{u}^{c'}_{\lambda}(0)\, \bar{d}^{b'}_{\alpha'}(0)\, \bar{u}^{Ta'}_{\beta'}(0)$$

$S_u^{aa'}(x)_{\alpha\beta'}$

$S_d^{bb'}(x)_{\beta\alpha'}$

$S_u^{cc'}(x)_{\delta\lambda}$

$S_u^{ac'}(x)_{\alpha\lambda}$

$S_u^{ca'}(x)_{\delta\beta'}$

sign ① → +

sign ② → −

− + +

① $$-4t^2\, (C\gamma_5)_{\alpha\beta}\, (\gamma C)_{\alpha'\beta'}\, 1_{\lambda\delta}\, 1_{\lambda'\delta'}\, S_u^{aa'}(x)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{cc'}(x)_{\delta\lambda}$$

② $$+4t^2\, (C\gamma_5)_{\alpha\beta}\, (\gamma C)_{\alpha'\beta'}\, 1_{\lambda\delta}\, 1_{\lambda'\delta'}\, S_u^{ac'}(x)_{\alpha\lambda}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{ca'}(x)_{\delta\beta'}$$

$$\Pi = i\epsilon_{abc}\,\epsilon_{a'b'c'} \int d^4x\, e^{ip\cdot x} \Big\langle -4\Big(C_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda\delta}\, (\gamma_5)_{\lambda'\delta'} \Big) \Big(S_u^{aa'}(x)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{cc'}(x)_{\delta\lambda'}$$

$$- S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{ac'}(x)_{\alpha\lambda'}\, S_u^{ca'}(x)_{\delta\beta'} \Big) - \Big(4t\, C_{\alpha\beta}\, (\gamma_5 C)_{\alpha'\beta'}\, 1_{\lambda'\delta'}\, (\gamma_5)_{\lambda\delta} \Big(S_u^{aa'}(x)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{cc'}(x)_{\delta\lambda'}$$

$$- S_u^{ac'}(x)_{\alpha\lambda'}\, S_u^{cc'}(x)_{\delta\lambda}\, S_u^{ca'}(x)_{\delta\beta'} \Big)\Big) - \Big(4t\, (C\gamma_5)_{\alpha\beta}\, C_{\alpha'\beta'}\, (\gamma_5)_{\lambda'\delta'}\, 1_{\lambda\delta} \Big(S_u^{aa'}(x)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{cc'}(x)_{\delta\lambda'}$$

$$- S_u^{ac'}(x)_{\alpha\lambda'}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{ca'}(x)_{\lambda'\beta'} \Big)\Big) - \Big(4t^2\, (C\gamma_5)_{\alpha\beta}\, (\gamma_5 C)_{\alpha'\beta'}\, 1_{\lambda\delta}\, 1_{\lambda'\delta'} \Big(S_u^{aa'}(x)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{cc'}(x)_{\delta\lambda}$$

$$- S_u^{ac'}(x)_{\alpha\lambda}\, S_d^{bb'}(x)_{\beta\alpha'}\, S_u^{ca'}(x)_{\delta\beta'} \Big)\Big\} \Big\rangle$$

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Term 1: $-4i\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big((\gamma_5)_{\lambda\delta}\, S_u^{cc'}(x)\, (\gamma_5)_{\lambda'\delta'} \Big[S_u^{aa'}(x)_{\beta'\alpha}\, \underbrace{C_{\alpha\beta}\, S_d^{bb'}(x)_{\beta\lambda'}\, C_{\lambda'\beta'}}_{\tilde{S}_d^{bb'}(x)_{\alpha\beta'}} \Big]$ (TV) [illegible]

$$- (\gamma_5)_{\lambda\delta}\, S_u^{ca'}(x)_{\delta\beta'}\, \underbrace{C_{\alpha\beta}\, S_d^{bb'}(x)_{\beta\lambda'}\, C_{\lambda'\beta'}}_{\tilde{S}_d^{bb'}(x)_{\alpha\beta'}}\, S_u^{ac'}(x)_{\alpha\lambda'}\, (\gamma_5)_{\lambda'\delta'} \Big)$$

$\boxed{\text{Term 1}}$ $-4i\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big(\gamma_5\, S_u^{cc'}\, \gamma_5\, \mathrm{Tr}\big(S_u^{aa'}(x)\, \tilde{S}_d^{bb'}(x) \big) - \gamma_5\, S_u^{ca'}(x)\, \tilde{S}_d^{bb'}(x)\, S_u^{ac'}(x)\, \gamma_5 \Big)$

Term 2: $-4i\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big((\gamma_5)_{\lambda\delta}\, S_u^{cc'}(x)_{\delta\lambda}\, I_{\lambda'\delta'}\, S_u^{aa'}(x)_{\alpha\beta'}\, \underbrace{(\gamma_5 C)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\lambda'}\, C_{\lambda\beta}}_{\tilde{S}_d^{bb'}(x)}$

$$- (\gamma_5)_{\lambda\delta}\, S_u^{ca'}(x)_{\delta\beta'}\, \underbrace{(\gamma_5 C)_{\alpha\beta'}\, S_d^{bb'}(x)_{\beta\lambda'}\, (C_{\alpha\beta})}_{\tilde{S}_d^{bb'}(x)}\, S_u^{c'a}(x)_{\alpha\lambda'}\, I_{\lambda'\delta'} \Big)$$

$\boxed{\text{Term 2}}$ $-4i\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big(\gamma_5\, S_u^{cc'}(x)\, \mathrm{Tr}\big(S_u^{aa'}(x)\, \gamma_5\, \tilde{S}_d^{bb'}(x) \big)$

$$- \gamma_5\, S_u^{ca'}(x)\, \gamma_5\, \tilde{S}_d^{bb'}(x)\, S_u^{c'a}(x) \Big)$$

Term 3: $-4t\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big(I_{\lambda\delta}\, S_u^{cc}(x)_{\delta\lambda'}\, (\gamma_5)_{\lambda'\delta'}\, S_u^{aa'}(x)_{\alpha\beta'}\, \underbrace{(C)_{\alpha'\beta'}\, S_d^{bb'}(x)_{\beta\lambda'}\, (C\gamma_5)_{\alpha\beta}}_{\tilde{S}_d^{bb'}(x)}$

$- I_{\lambda\delta}\, S_u^{ca'}(x)_{\alpha\beta'}\, \underbrace{C_{\alpha'\beta'}\, S_d^{bb'}(x)_{\beta\lambda'}\, (C\gamma_5)_{\alpha\beta}}_{\tilde{S}_d^{bb'}(x)}\, S_u^{ac'}(x)_{\alpha\lambda'}\, (\gamma_5)_{\lambda'\delta'} \Big)$

$\boxed{\text{Term 3}}$ $-4t\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big(S_u^{cc}(x)\,\gamma_5\,\mathrm{Tr}\big(S_u^{aa'}(x)\,\tilde{S}_d^{bb'}(x)\,\gamma_5\big)$

$- S_u^{ca'}(x)\,\tilde{S}_d^{bb'}(x)\,\gamma_5\, S_u^{ac'}(x)\,\gamma_5 \Big)$

Term 4: $-4t'\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big(I_{\lambda\delta}\, S_u^{cc'}(x)_{\delta\lambda}\, I_{\lambda'\delta'}\, S_d^{bb'}(x)_{\beta\alpha}\, \underbrace{(\gamma_5 C)_{\alpha\beta'}\, S_u^{cc'}(x)_{\delta\lambda}\, (C\gamma_5)_{\alpha\beta'}}_{\tilde{S}_u^{cc'}(x)} -$

$I_{\lambda\delta}\, S_u^{ca'}(x)_{\delta\beta'}\, \underbrace{(\gamma_5 C)_{\alpha'\beta'}\, S_d^{bb'}(x)_{\beta\lambda'}\, (C\gamma_5)}_{\tilde{S}_d^{bb'}(x)}{}_{\alpha\beta}\, S_u^{a'c}(x)_{\delta\beta'} \Big)$

$\boxed{\text{Term 4:}}$

$-4t'\,\epsilon_{abc}\,\epsilon_{a'b'c'}\Big(S_u^{cc'}(x)\,\mathrm{Tr}\big(S_d^{bb'}(x)\,\gamma_5\,\tilde{S}_u^{cc'}(x)\,\gamma_5\big) -$

$S_u^{ca'}(x)\,\gamma_5\,\tilde{S}_d^{bb'}(x)\,\gamma_5\, S_u^{a'c}(x) \Big)$

$$
\begin{aligned}
\Pi(p) = 4i\,\epsilon_{abc}\,\epsilon_{a'b'c'} \int d^4x\, e^{ip\cdot x} \Big\langle \Big\{ & \gamma_5\, S_u^{ca'}(x)\, \tilde{S}_d^{bb'}(x)\, S_u^{ac'}(x)\, \gamma_5 - \gamma_5\, S_u^{cc'}\, \gamma_5\, \mathrm{Tr}\big(S_u^{aa'}(x)\, \tilde{S}_d^{bb'}(x) \big) \\
& + t \Big(\gamma_5\, S_u^{ca'}(x)\, \gamma_5\, \tilde{S}_d^{bb'}(x)\, S_u^{c'a}(x) + S_u^{ca'}(x)\, \tilde{S}_d^{bb'}(x)\, \gamma_5\, S_u^{ac'}(x)\, \gamma_5 \\
& \quad - \gamma_5\, S_u^{cc'}(x)\, \mathrm{Tr}\big(S_u^{aa'}(x)\, \gamma_5\, \tilde{S}_d^{bb'}(x) \big) - S_u^{cc}(x)\, \gamma_5\, \mathrm{Tr}\big(S_u^{aa'}(x)\, \tilde{S}_d^{bb'}(x)\, \gamma_5 \big) \Big) \\
& + t^2 \Big(S_u^{ca'}(x)\, \gamma_5\, \tilde{S}_d^{bb'}(x)\, \gamma_5\, S_u^{a'c}(x) - S_u^{cc'}(x)\, \mathrm{Tr}\big(S_d^{bb'}(x)\, \gamma_5\, \tilde{S}_u^{cc'}(x)\, \gamma_5 \big) \Big) \Big\} \Big\rangle
\end{aligned}
$$