Intrinsic three-body nuclear forces in a compact tribaryon configuration

(Quarks and Compact Stars 2019)

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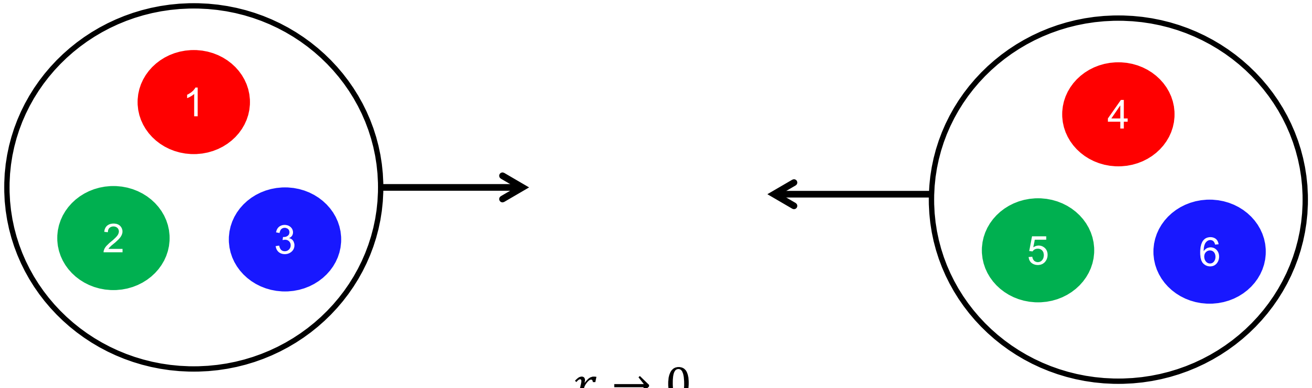
1. BB Interaction

A. Park, T. Hatsuda, T. Inoue, S. H. Lee, arXiv:1907.06351

2. BBB Interaction

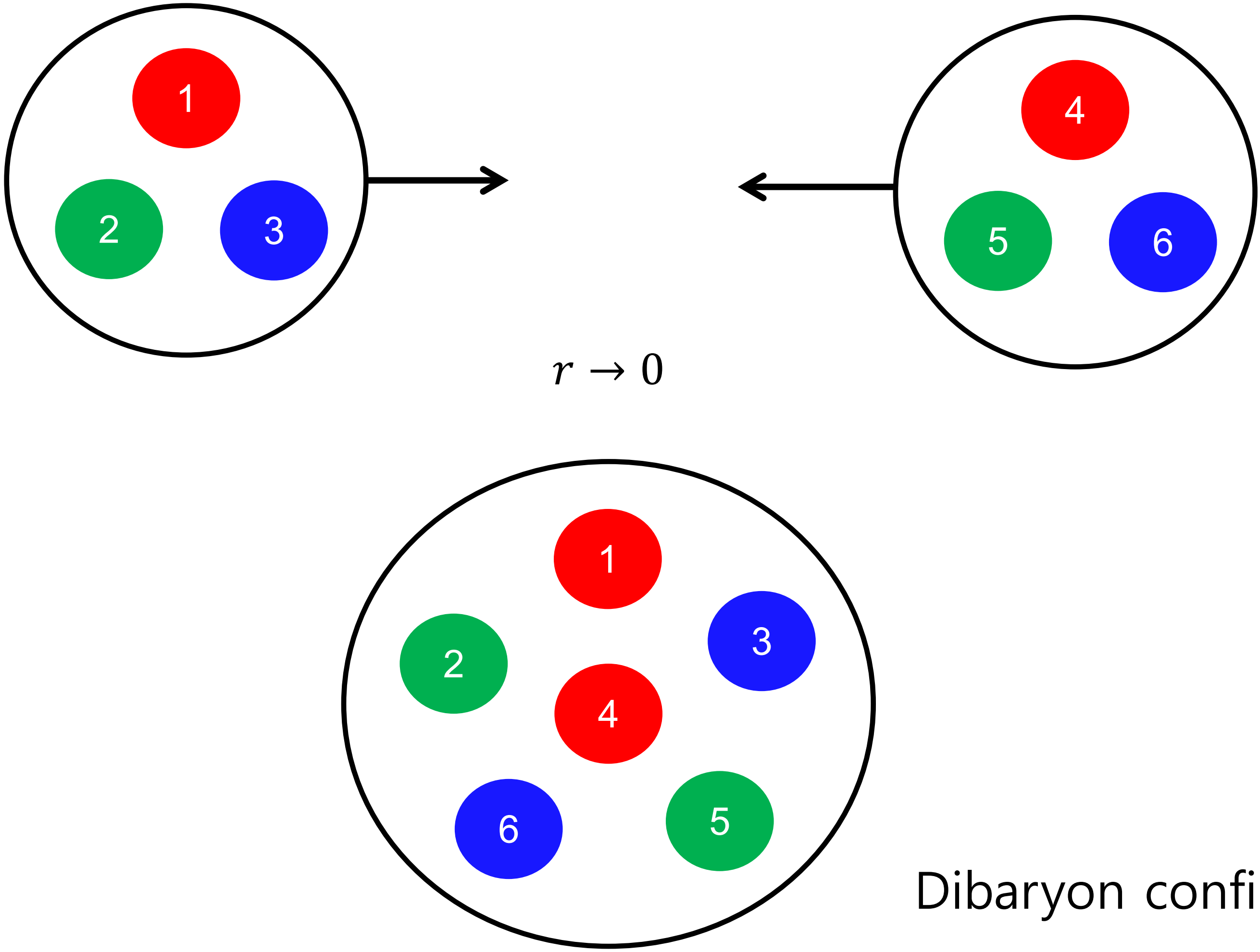
A. Park, S. H. Lee, arXiv:1908.08333

Baryon-baryon interaction



$r \to 0$

Baryon-baryon interaction



$r \to 0$

Dibaryon configuration

Baryon-baryon interaction - Flavor state

baryon ⊗ baryon → dibaryon

$$8 \otimes 8 = 1 \oplus 8 \oplus 8 \oplus 10 \oplus \bar{10} \oplus 27$$

$$8 \otimes 10 = 8 \oplus 10 \oplus 27 \oplus 35$$

$$10 \otimes 10 = \bar{10} \oplus 27 \oplus 28 \oplus 35.$$

Baryon-baryon interaction in Quark Model

baryon ⊗ baryon → dibaryon

$$8 \otimes 8 = 1 \oplus 8 \oplus 8 \oplus 10 \oplus \overline{10} \oplus 27$$
$$8 \otimes 10 = 8 \oplus 10 \oplus 27 \oplus 35$$
$$10 \otimes 10 = \overline{10} \oplus 27 \oplus 28 \oplus 35.$$

Wave function = Orbital ⊗ Color ⊗ Flavor ⊗ Spin

$[6]_O$ $[222]_C$ $[33]_{FS}$

$$H_{CS} = -\sum_{i<j} \lambda_i^c \lambda_j^c \sigma_i \cdot \sigma_j$$
$$= N(N-10) + \frac{4}{3}S(S+1) + 4C_F + 2C_C$$

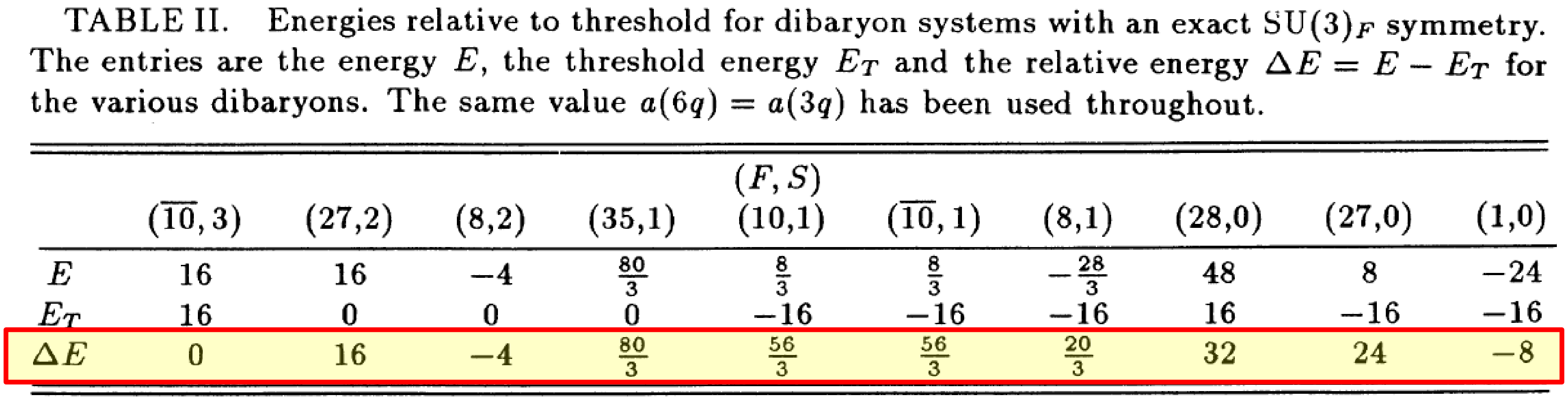


TABLE II. Energies relative to threshold for dibaryon systems with an exact $SU(3)_F$ symmetry. The entries are the energy E, the threshold energy E_T and the relative energy $\Delta E = E - E_T$ for the various dibaryons. The same value $a(6q) = a(3q)$ has been used throughout.

					(F,S)					
	$(\overline{10},3)$	(27,2)	(8,2)	(35,1)	(10,1)	$(\overline{10},1)$	(8,1)	(28,0)	(27,0)	(1,0)
E	16	16	-4	$\frac{80}{3}$	$\frac{8}{3}$	$\frac{8}{3}$	$-\frac{28}{3}$	48	8	-24
E_T	16	0	0	0	-16	-16	-16	16	-16	-16
ΔE	0	16	-4	$\frac{80}{3}$	$\frac{56}{3}$	$\frac{56}{3}$	$\frac{20}{3}$	32	24	-8

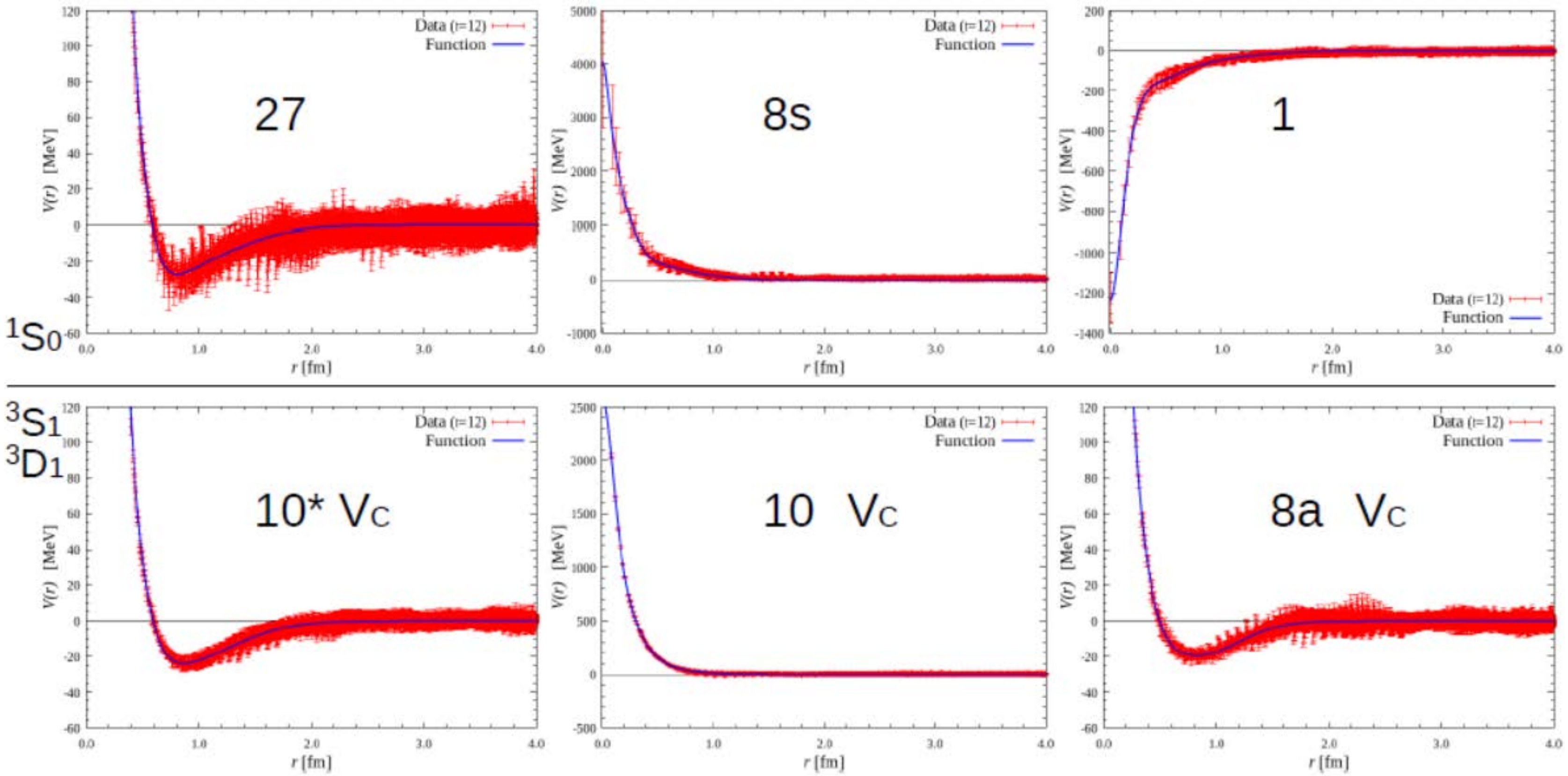
$d^*(2380)$ $N\Omega$ $\Omega\Omega$ H dibaryon

B. Silvestre-Brac and J. Leandri, Phys. Rev. D 45, 4221 (1992)

Baryon-baryon interaction in lattice QCD (SU(3) broken)

BB S-wave potentials

(96,96) src
$t - t_0 = 12$



$$8 \times 8 = \underbrace{27 + 8s + 1}_{^1S_0} + \underbrace{10^* + 10 + 8a}_{^3S_1\ ,\ ^3D_1}$$

28

$M_\pi \simeq 146$, $M_K \simeq 525$ MeV

almost physical point

$M_N \simeq 956$, $M_\Lambda \simeq 1121$, $M_\Sigma \simeq 1201$, $M_\Xi \simeq 1328$ MeV

T. Inoue, QNP2018 conference

Hamiltonian

$$H = \sum_{i=1}^{6}(m_i + \frac{\mathbf{p}_i^2}{2m_i}) - \frac{3}{16}\sum_{i<j}^{6}\lambda_i^c\lambda_j^c(V_{ij}^C + V_{ij}^{SS}).$$

$$V_{ij}^C = -\frac{\kappa}{r_{ij}} + \frac{r_{ij}}{a_0} - D.$$

: confinement potential

$$V_{ij}^{SS} = \frac{\hbar^2 c^2 \kappa'}{m_i m_j c^4}\frac{1}{(r_{0ij})^2 r_{ij}} e^{-(r_{ij})^2/(r_{0ij})^2}\sigma_i \cdot \sigma_j$$

: hyperfine potential

$$r_{0ij} = 1/\left(\alpha + \beta\frac{m_i m_j}{m_i + m_j}\right)$$

TABLE I: Parameters fitted to the experimental baryon masses using the variational method with a single Gaussian. The respective units are given in the third row

κ	κ'	a_0	D	α	β	m_q	m_s
0.59	0.5	5.386	0.96	2.1	0.552	0.343	0.632
		GeV^{-2}	GeV	fm^{-1}		GeV	GeV

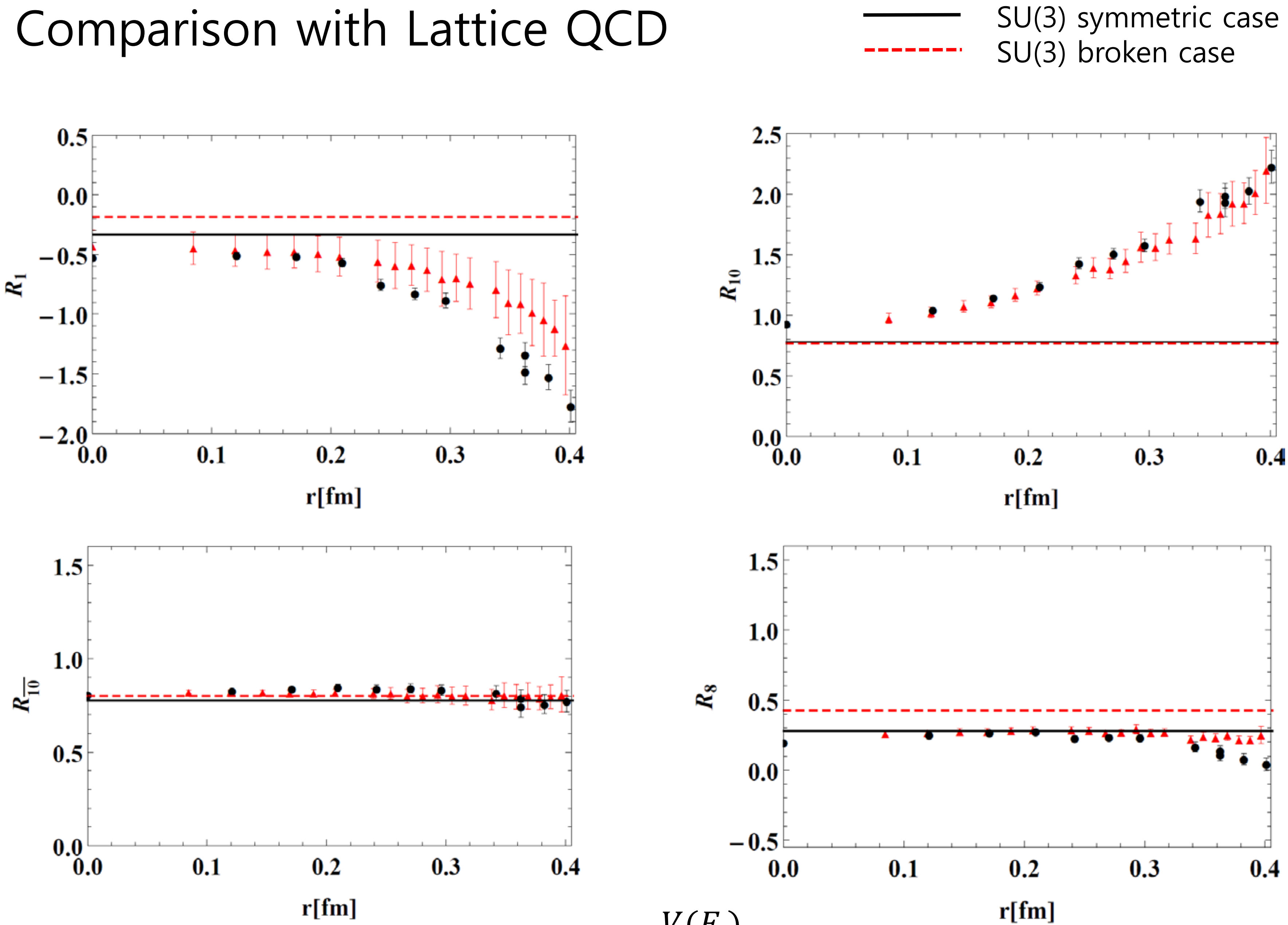
Baryon-baryon interaction in Quark model

$$V_{\rm CQM} = \langle H \rangle_{6q} - E_{BB'},$$
$$E_{BB'} = M_B + M_{B'} + K_{{\rm rel},BB'}.$$

$$V_{\rm CQM}(F_1) = \langle H \rangle_{F_1} - \left[\frac{1}{8}E_{\Lambda\Lambda} + \frac{3}{8}E_{\Sigma\Sigma} + \frac{1}{2}E_{N\Xi}\right],$$
$$V_{\rm CQM}(F_{27}) = \langle H \rangle_{F_{27}} - \left[\frac{27}{40}E_{\Lambda\Lambda} + \frac{1}{40}E_{\Sigma\Sigma} + \frac{3}{10}E_{N\Xi}\right],$$
$$V_{\rm CQM}(F_{10}) = \langle H \rangle_{F_{10}} - \left[\frac{1}{2}E_{\Sigma\Lambda} + \frac{1}{6}E_{\Sigma\Sigma} + \frac{1}{3}E_{N\Xi}\right],$$
$$V_{\rm CQM}(F_{\overline{10}}) = \langle H \rangle_{F_{\overline{10}}} - \left[\frac{1}{2}E_{\Sigma\Lambda} + \frac{1}{6}E_{\Sigma\Sigma} + \frac{1}{3}E_{N\Xi}\right],$$
$$V_{\rm CQM}(F_8) = \langle H \rangle_{F_8} - E_{N\Xi}.$$

$$R_l = \frac{V(F_l)}{V(F_{27})}$$

Comparison with Lattice QCD



$$R_l = \frac{V(F_l)}{V(F_{27})}$$

1. BB Interaction

- collaborated with T. Hatsuda, T. Inoue, S. H. Lee

2. BBB Interaction

- collaborated with S. H. Lee

Hyperon puzzle in neutron stars

Massive ($2M_{\odot}$) neutron stars vs softening of EOS by hyperon mixing

→ Hyperon puzzle

Hyperon puzzle in neutron stars

Massive ($2M_{\odot}$) neutron stars vs softening of EOS by hyperon mixing

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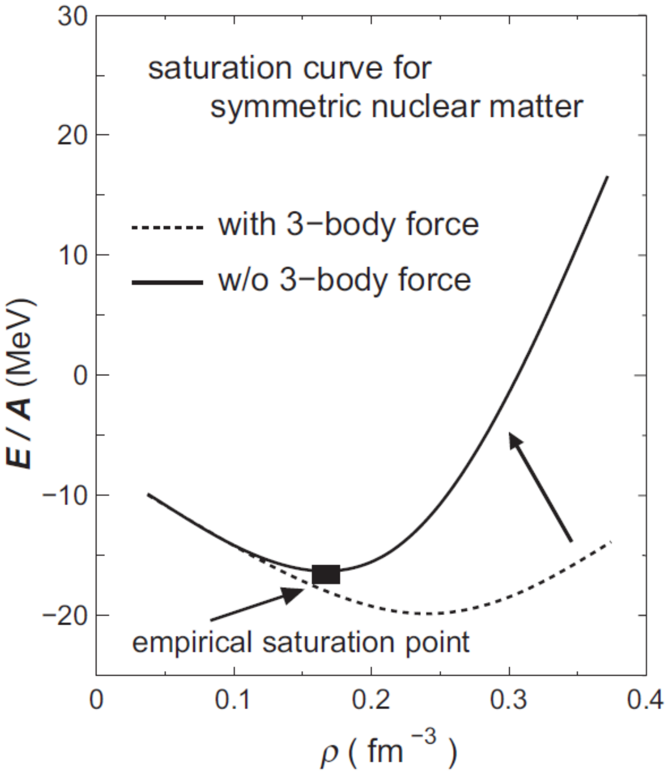
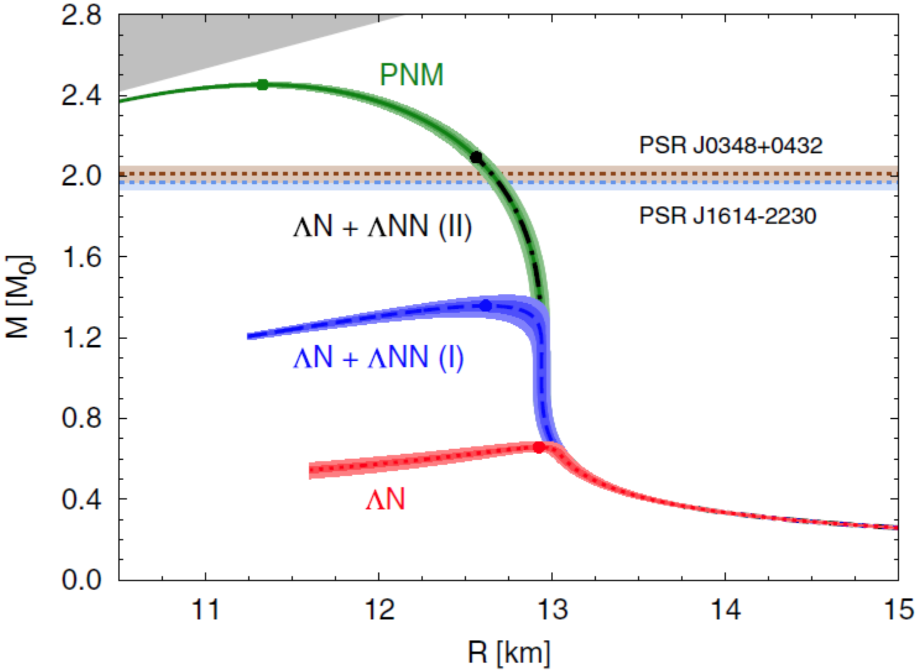
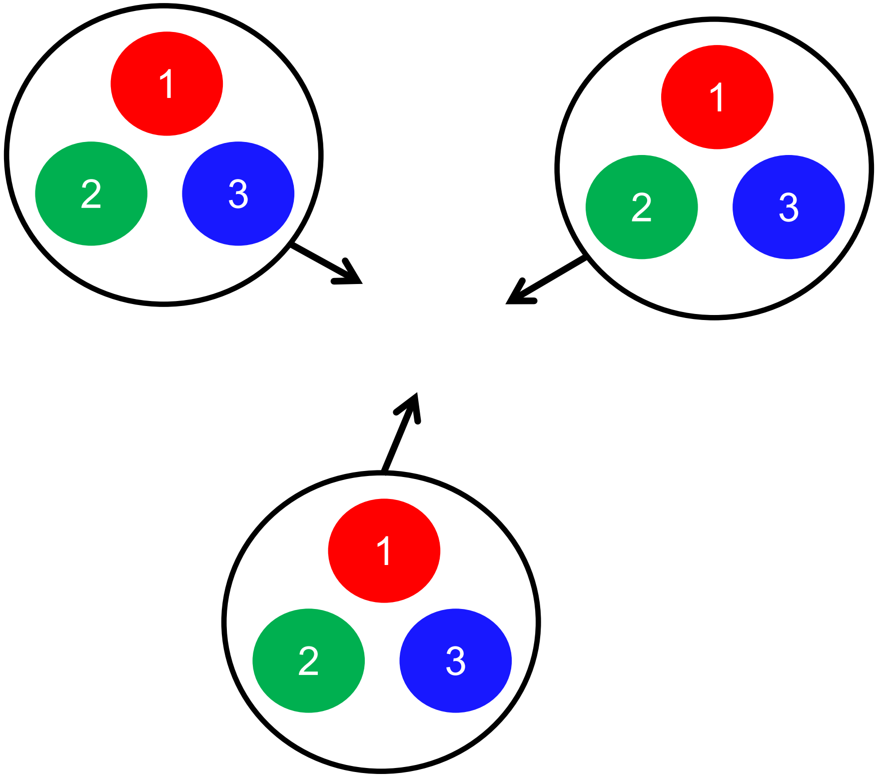


Y. Sakuragi, PTEP 2016 (2016) 06A106

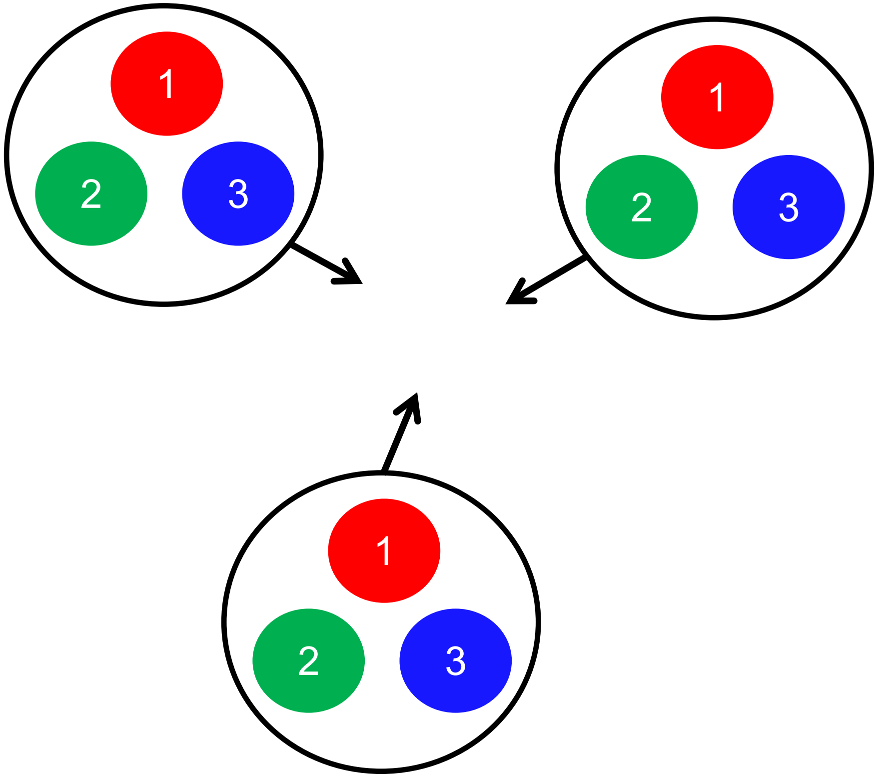


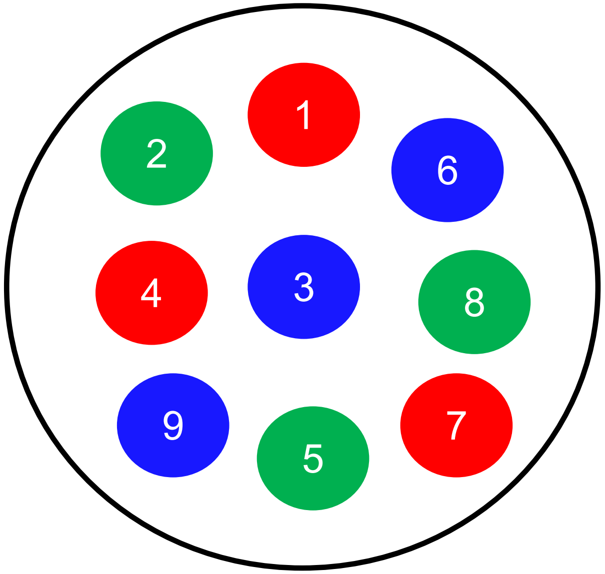
D. Lonardoni et al, PRL 114, 092301 (2015)

Three-body interaction



Three-body interaction





Tribaryon configuration

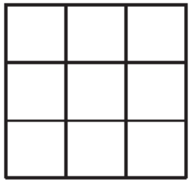
Flavor state of the tribaryon

Wave function = Orbital ⊗ Color ⊗ Flavor ⊗ Spin

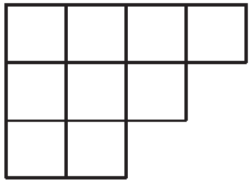
[9] [333]

$$[333]_{FS} = [63]_F \otimes [63]_S + [54]_F \otimes [54]_S + [621]_F \otimes [54]_S + [531]_F \otimes [72]_S + [531]_F \otimes [63]_S + [531]_F \otimes [54]_S + [522]_F \otimes [63]_S + [441]_F \otimes [63]_S + [432]_F \otimes [81]_S + [432]_F \otimes [72]_S + [432]_F \otimes [63]_S + [432]_F \otimes [54]_S + [333]_F \otimes [9]_S + [333]_F \otimes [72]_S + [333]_F \otimes [63]_S.$$

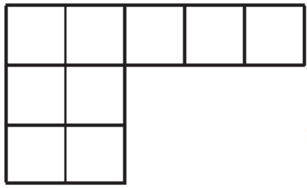
Flavor and spin states of tribaryon :



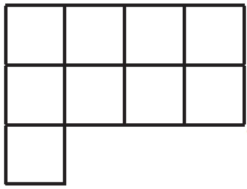
$\mathbf{1}(S = \frac{3}{2}, \frac{5}{2}, \frac{9}{2})$,



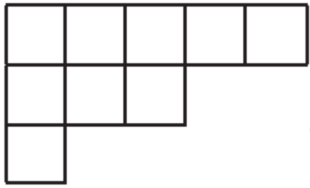
$\mathbf{8}(S = \frac{1}{2}, \frac{3}{2}, \frac{5}{2}, \frac{7}{2})$,



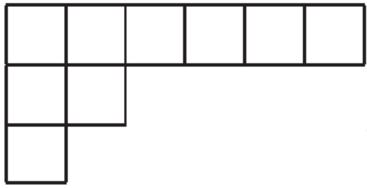
$\mathbf{10}(S = \frac{3}{2})$,



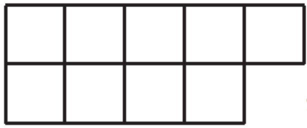
$\overline{\mathbf{10}}(S = \frac{3}{2})$,



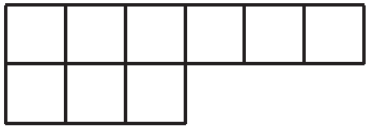
$\mathbf{27}(S = \frac{1}{2}, \frac{3}{2}, \frac{5}{2})$,



$\mathbf{35}(S = \frac{1}{2})$,



$\overline{\mathbf{35}}(S = \frac{1}{2})$,



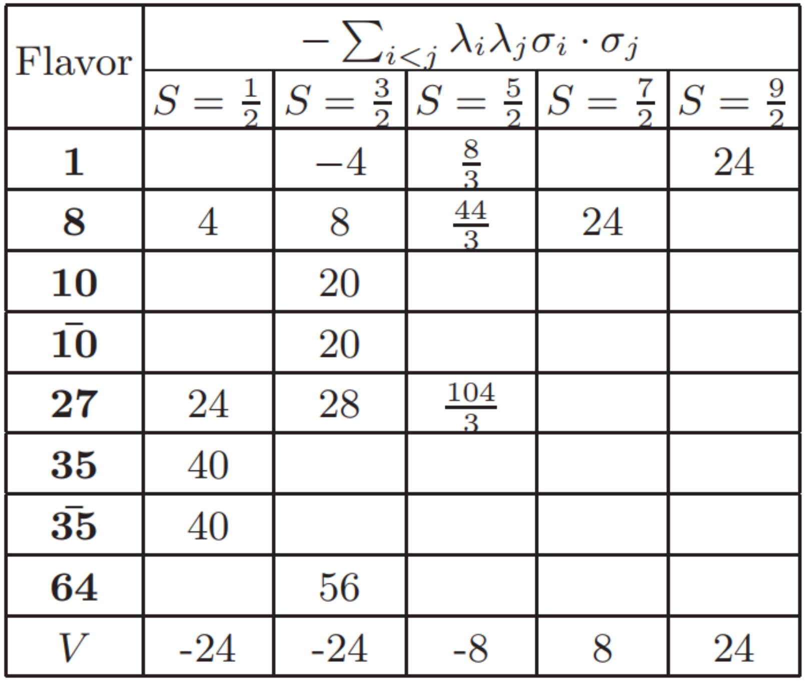
$\mathbf{64}(S = \frac{3}{2})$

QCS 2019

Color-spin interaction

SU(3) flavor symmetric limit

$$K = -\sum_{i<j} \lambda_i^c \lambda_j^c \sigma_i \cdot \sigma_j$$
$$= N(N-10) + \frac{4}{3}S(S+1) + 4C_F + 2C_C$$



$K_{tribaryon}$

$K_{B1} + K_{B2} + K_{B3} \rightarrow$

Flavor	$-\sum_{i<j} \lambda_i \lambda_j \sigma_i \cdot \sigma_j$				
	$S=\frac{1}{2}$	$S=\frac{3}{2}$	$S=\frac{5}{2}$	$S=\frac{7}{2}$	$S=\frac{9}{2}$
1		-4	$\frac{8}{3}$		24
8	4	8	$\frac{44}{3}$	24	
10		20			
$\overline{\mathbf{10}}$		20			
27	24	28	$\frac{104}{3}$		
35	40				
$\overline{\mathbf{35}}$	40				
64		56			
V	-24	-24	-8	8	24

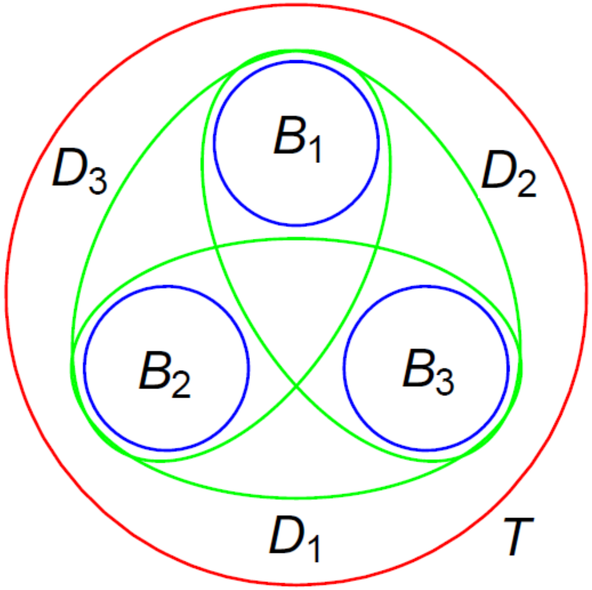
TABLE I: The expectation value of color-spin interaction of the tribaryon for each flavor in SU(3) flavor symmetry. Empty boxes represent states that are not allowed by Pauli principle. V is for the lowest threshold three baryon states.

Pure three-body force

$$E_{2-\mathrm{body},i} = M_{D,i} - M_{B_{i,1}} - M_{B_{i,2}}$$

$$M_{\mathrm{tribaryon}} = \sum_{i=1}^{3} E_{2-\mathrm{body},i} + E_{3-\mathrm{body}} + \sum_{i=1}^{3} M_{B_i}$$

$$\begin{aligned} E_{3-\mathrm{body}} &= M_{\mathrm{tribaryon}} - \sum_{i=1}^{3} E_{2-\mathrm{body},i} - \sum_{i=1}^{3} M_{B_i} \\ &= M_{\mathrm{tribaryon}} - \sum_{i=1}^{3} M_{\mathrm{dibaryon},i} + \sum_{i=1}^{3} M_{B_i} \end{aligned}$$



Transformation coefficients

Baryon ⊗ baryon

Dibaryon

D(F,S)	$B_1 \otimes B_2$		
	$8 \otimes 8$	$8 \otimes 10$	$10 \otimes 10$
(1,0)	1		
(8,1)	$\frac{4}{9}$	$\frac{5}{9}$	
(8,2)		1	
(10,1)	$\frac{1}{9}$	$\frac{8}{9}$	
$(\overline{10},1)$	$\frac{5}{9}$		$\frac{4}{9}$
$(\overline{10},3)$			1
(27,0)	$\frac{5}{9}$		$\frac{4}{9}$
(27,2)		$\frac{4}{9}$	$\frac{5}{9}$
(28,0)			1
(35,1)		$\frac{4}{9}$	$\frac{5}{9}$

$$\langle F_1 \rangle = \langle F_8 \otimes F_8 \rangle = \frac{1}{8}\Lambda\Lambda + \frac{3}{8}\Sigma\Sigma + \frac{1}{2}N\Xi$$

$$\begin{aligned}\langle F_{27} \rangle &= \frac{5}{9}\langle F_8 \otimes F_8 \rangle + \frac{4}{9}\langle F_{10} \otimes F_{10} \rangle \\ &= \frac{5}{9}(\frac{27}{40}\Lambda\Lambda + \frac{1}{40}\Sigma\Sigma + \frac{3}{10}N\Xi) + \frac{4}{9}\Sigma^*\Sigma^*\end{aligned}$$

$$\begin{aligned}\langle F_{10} \rangle &= \frac{1}{9}\langle F_8 \otimes F_8 \rangle + \frac{8}{9}\langle F_8 \otimes F_{10} \rangle \\ &= \frac{1}{9}(\frac{1}{2}\Sigma\Lambda + \frac{1}{6}\Sigma\Sigma + \frac{1}{3}N\Xi) + \frac{8}{9}(\frac{1}{3}\Sigma\Sigma^* + \frac{1}{3}N\Xi^* + \frac{1}{3}\Xi\Delta)\end{aligned}$$

$$\begin{aligned}\langle F_{\overline{10}} \rangle &= \frac{5}{9}\langle F_8 \otimes F_8 \rangle + \frac{4}{9}\langle F_{10} \otimes F_{10} \rangle \\ &= \frac{5}{9}(\frac{1}{2}\Sigma\Lambda + \frac{1}{6}\Sigma\Sigma + \frac{1}{3}N\Xi) + \frac{4}{9}(\frac{1}{3}\Sigma^*\Sigma^* + \frac{2}{3}\Delta\Xi^*)\end{aligned}$$

$$\begin{aligned}\langle F_8 \rangle &= \frac{4}{9}\langle F_8 \otimes F_8 \rangle + \frac{5}{9}\langle F_8 \otimes F_{10} \rangle \\ &= \frac{4}{9}N\Xi + \frac{5}{9}(\frac{3}{5}\Sigma\Sigma^* + \frac{2}{5}N\Xi^*)\end{aligned}$$

$$T_2(\mathrm{D}, \mathrm{B} \otimes \mathrm{B}) = \langle \Psi_{\mathrm{dibaryon}} | \Psi_{\mathrm{baryon}} \otimes \Psi_{\mathrm{baryon}} \rangle^2$$

Transformation coefficients

Tribaryon → Baryon ⊗ Dibaryon

$$T_3(\mathrm{T}, \mathrm{B} \otimes \mathrm{D}) = \langle \Psi_{\mathrm{tribaryon}} | \Psi_{\mathrm{baryon}} \otimes \Psi_{\mathrm{dibaryon}} \rangle^2$$

Transformation coefficients

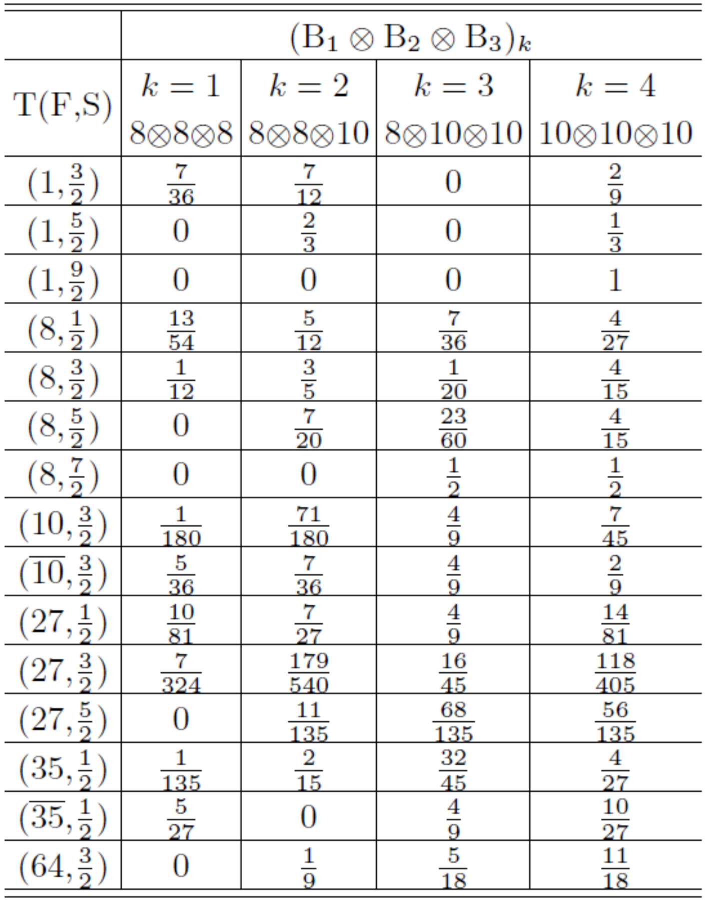
Tribaryon → Baryon ⊗ Dibaryon

Tribaryon

Baryon ⊗ Dibaryon

B(F,S) ⊗ D(F,S)	T(F,S)														
	$(1,\frac{3}{2})$	$(1,\frac{5}{2})$	$(1,\frac{9}{2})$	$(8,\frac{1}{2})$	$(8,\frac{3}{2})$	$(8,\frac{5}{2})$	$(8,\frac{7}{2})$	$(10,\frac{3}{2})$	$(\overline{10},\frac{3}{2})$	$(27,\frac{1}{2})$	$(27,\frac{3}{2})$	$(27,\frac{5}{2})$	$(35,\frac{1}{2})$	$(\overline{35},\frac{1}{2})$	$(64,\frac{3}{2})$
$(8,\frac{1}{2})\otimes(1,0)$				$\frac{1}{16}$											
$(8,\frac{1}{2})\otimes(8,1)$	$\frac{7}{16}$			$\frac{1}{6}$	$\frac{1}{8}$			$\frac{1}{240}$	$\frac{5}{48}$	$\frac{10}{81}$	$\frac{7}{1296}$				
$(8,\frac{1}{2})\otimes(8,2)$	$\frac{7}{48}$	$\frac{4}{9}$			$\frac{43}{200}$	$\frac{7}{50}$		$\frac{9}{80}$	$\frac{1}{80}$		$\frac{21}{400}$	$\frac{2}{675}$			
$(8,\frac{1}{2})\otimes(10,1)$				$\frac{5}{24}$	$\frac{1}{8}$			$\frac{1}{30}$		$\frac{5}{162}$	$\frac{7}{81}$		$\frac{1}{30}$		
$(8,\frac{1}{2})\otimes(\overline{10},1)$				$\frac{1}{24}$	$\frac{1}{40}$				$\frac{1}{6}$	$\frac{1}{162}$	$\frac{7}{405}$			$\frac{1}{6}$	
$(8,\frac{1}{2})\otimes(\overline{10},3)$						$\frac{1}{90}$	$\frac{1}{6}$					$\frac{14}{135}$			
$(8,\frac{1}{2})\otimes(27,0)$				$\frac{5}{48}$						$\frac{1}{9}$			$\frac{1}{150}$	$\frac{1}{6}$	
$(8,\frac{1}{2})\otimes(27,2)$					$\frac{1}{100}$	$\frac{21}{100}$		$\frac{1}{30}$	$\frac{2}{15}$		$\frac{31}{225}$	$\frac{26}{225}$			$\frac{1}{12}$
$(8,\frac{1}{2})\otimes(28,0)$													$\frac{4}{25}$		
$(8,\frac{1}{2})\otimes(35,1)$								$\frac{7}{30}$		$\frac{14}{81}$	$\frac{5}{81}$		$\frac{2}{15}$		$\frac{1}{12}$
$(10,\frac{3}{2})\otimes(1,0)$								$\frac{1}{40}$							
$(10,\frac{3}{2})\otimes(8,1)$				$\frac{5}{48}$	$\frac{1}{40}$	$\frac{7}{80}$		$\frac{1}{6}$		$\frac{5}{81}$	$\frac{7}{405}$	$\frac{4}{135}$	$\frac{1}{15}$		
$(10,\frac{3}{2})\otimes(8,2)$				$\frac{1}{80}$	$\frac{1}{600}$	$\frac{361}{3600}$	$\frac{2}{15}$	$\frac{1}{10}$		$\frac{1}{15}$	$\frac{7}{75}$	$\frac{28}{675}$	$\frac{1}{5}$		
$(10,\frac{3}{2})\otimes(10,1)$									$\frac{1}{6}$	$\frac{8}{81}$	$\frac{7}{162}$	$\frac{2}{27}$	$\frac{2}{15}$		
$(10,\frac{3}{2})\otimes(\overline{10},1)$	$\frac{7}{20}$	$\frac{2}{5}$		$\frac{1}{6}$	$\frac{9}{100}$	$\frac{7}{50}$				$\frac{7}{81}$	$\frac{529}{8100}$	$\frac{7}{675}$			$\frac{1}{30}$
$(10,\frac{3}{2})\otimes(\overline{10},3)$	$\frac{1}{15}$	$\frac{7}{45}$	1		$\frac{7}{75}$	$\frac{16}{225}$	$\frac{1}{4}$				$\frac{7}{75}$	$\frac{98}{675}$			$\frac{7}{40}$
$(10,\frac{3}{2})\otimes(27,0)$					$\frac{1}{4}$			$\frac{7}{120}$	$\frac{1}{12}$		$\frac{1}{9}$				$\frac{1}{30}$
$(10,\frac{3}{2})\otimes(27,2)$				$\frac{2}{15}$	$\frac{1}{25}$	$\frac{6}{25}$	$\frac{9}{20}$	$\frac{7}{30}$	$\frac{1}{3}$	$\frac{7}{45}$	$\frac{4}{225}$	$\frac{49}{225}$	$\frac{2}{15}$	$\frac{1}{3}$	$\frac{5}{24}$
$(10,\frac{3}{2})\otimes(28,0)$															$\frac{7}{40}$
$(10,\frac{3}{2})\otimes(35,1)$										$\frac{7}{81}$	$\frac{16}{81}$	$\frac{7}{27}$	$\frac{2}{15}$	$\frac{1}{3}$	$\frac{5}{24}$

Probability of three-baryon channels



T(F,S)	$(\mathrm{B}_1 \otimes \mathrm{B}_2 \otimes \mathrm{B}_3)_k$			
	$k = 1$ $8{\otimes}8{\otimes}8$	$k = 2$ $8{\otimes}8{\otimes}10$	$k = 3$ $8{\otimes}10{\otimes}10$	$k = 4$ $10{\otimes}10{\otimes}10$
$(1,\frac{3}{2})$	$\frac{7}{36}$	$\frac{7}{12}$	0	$\frac{2}{9}$
$(1,\frac{5}{2})$	0	$\frac{2}{3}$	0	$\frac{1}{3}$
$(1,\frac{9}{2})$	0	0	0	1
$(8,\frac{1}{2})$	$\frac{13}{54}$	$\frac{5}{12}$	$\frac{7}{36}$	$\frac{4}{27}$
$(8,\frac{3}{2})$	$\frac{1}{12}$	$\frac{3}{5}$	$\frac{1}{20}$	$\frac{4}{15}$
$(8,\frac{5}{2})$	0	$\frac{7}{20}$	$\frac{23}{60}$	$\frac{4}{15}$
$(8,\frac{7}{2})$	0	0	$\frac{1}{2}$	$\frac{1}{2}$
$(10,\frac{3}{2})$	$\frac{1}{180}$	$\frac{71}{180}$	$\frac{4}{9}$	$\frac{7}{45}$
$(\overline{10},\frac{3}{2})$	$\frac{5}{36}$	$\frac{7}{36}$	$\frac{4}{9}$	$\frac{2}{9}$
$(27,\frac{1}{2})$	$\frac{10}{81}$	$\frac{7}{27}$	$\frac{4}{9}$	$\frac{14}{81}$
$(27,\frac{3}{2})$	$\frac{7}{324}$	$\frac{179}{540}$	$\frac{16}{45}$	$\frac{118}{405}$
$(27,\frac{5}{2})$	0	$\frac{11}{135}$	$\frac{68}{135}$	$\frac{56}{135}$
$(35,\frac{1}{2})$	$\frac{1}{135}$	$\frac{2}{15}$	$\frac{32}{45}$	$\frac{4}{27}$
$(\overline{35},\frac{1}{2})$	$\frac{5}{27}$	0	$\frac{4}{9}$	$\frac{10}{27}$
$(64,\frac{3}{2})$	0	$\frac{1}{9}$	$\frac{5}{18}$	$\frac{11}{18}$

TABLE III. Probability $P(\mathrm{T}, (\mathrm{B}_1{\otimes}\mathrm{B}_2{\otimes}\mathrm{B}_3)_k)$ of three-baryon channels for each tribaryon configurations. The first column represents tribaryon configurations.

Intrinsic Three-body force

$$V_3^{(\mathrm{B}_1\otimes\mathrm{B}_2\otimes\mathrm{B}_3)_k} = M_\mathrm{T} - 3\sum_{j=1}^{n}\frac{1}{P(\mathrm{T},(\mathrm{B}_1\otimes\mathrm{B}_2\otimes\mathrm{B}_3)_k)}T_3(\mathrm{T},\mathrm{B}_1\otimes\mathrm{D}_j)T_2(\mathrm{D}_j,\mathrm{B}_2\otimes\mathrm{B}_3)M_{\mathrm{D},j} + \sum_{i=1}^{3}M_{\mathrm{B}_i}$$

For $F = 8, S = 1/2$, the possible baryon ⊗ dibaryon states are

$$\begin{aligned}(F,S) = {} & (8,1/2)\otimes(1,0),\\ & (8,1/2)\otimes(8,1),\\ & (8,1/2)\otimes(10,1),\\ & (8,1/2)\otimes(\overline{10},1),\\ & (8,1/2)\otimes(27,0).\end{aligned}$$

Their ratios are $\frac{27}{104}:\frac{4}{13}:\frac{5}{52}:\frac{5}{52}:\frac{25}{104}$.

$$V_3{}^{8\otimes8\otimes8}\left(F=8, S=\frac{1}{2}\right)$$

$$= \left(4-3\left\{\frac{27}{104}(-24)+\frac{4}{13}\left(-\frac{28}{3}\right)+\frac{5}{52}\left(\frac{8}{3}\right)+\frac{5}{52}\left(\frac{8}{3}\right)+\frac{25}{104}(8)\right\}+(-8-8-8)\right)I_g$$

$$= 0$$

Intrinsic Three-body force

$$V_3^{(\mathrm{B}_1\otimes\mathrm{B}_2\otimes\mathrm{B}_3)_k} = M_\mathrm{T} - 3\sum_{j=1}^{n}\frac{1}{P(\mathrm{T},(\mathrm{B}_1\otimes\mathrm{B}_2\otimes\mathrm{B}_3)_k)}T_3(\mathrm{T},\mathrm{B}_1\otimes\mathrm{D}_j)T_2(\mathrm{D}_j,\mathrm{B}_2\otimes\mathrm{B}_3)M_{\mathrm{D},j} + \sum_{i=1}^{3}M_{\mathrm{B}_i}$$

$$\begin{aligned} V_3 &= \sum_{k=1}^{4}P(T,(B_1\otimes B_2\otimes B_3)_k)V_3^{(B_1\otimes B_2\otimes B_3)_k} \\ &= M_\mathrm{T} - 3\sum_{j=1}^{n}T_3(\mathrm{T},\mathrm{B}_{j_1}\otimes\mathrm{D}_j)T_2(\mathrm{D}_j,\mathrm{B}_{j_2}\otimes\mathrm{B}_{j_3})M_{\mathrm{D},j} + \sum_{k=1}^{4}P(\mathrm{T},(\mathrm{B}_1\otimes\mathrm{B}_2\otimes\mathrm{B}_3)_k)\sum_{i=1}^{3}M_{\mathrm{B}_i} \\ &= 0 \end{aligned}$$

Flavor-Spin interaction

$$\begin{aligned} &-\sum_{i<j}^{N}\lambda_i^F\lambda_j^F\sigma_i\cdot\sigma_j \\ &\qquad = N(N-10) + \frac{4}{3}S(S+1) + 2C_F + 4C_C \end{aligned}$$

$$V_3 = 0$$

Summary

1. We have calculated the transformation coefficients of tribaryon with flavor SU(3) symmetry to investigate the intrinsic three-body interaction.

2. We found that the intrinsic three-baryon interaction at short distance vanishes for all quantum numbers in flavor SU(3) symmetric limit.

3. It should be noted that in a realistic flavor SU(3) breaking case, the cancellation will not be exact. Hence, we need to look at the intrinsic three-body interaction with realistic strange quark mass taking into account the spatial dependence that will be different for all quark pairs.

Thank you