Quark-Pauli effect in the three-baryon systems consisted of baryon-octet

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1. Introduction
2. Formulation
3. Results
4. Summary

1. Introduction

Three-body force in the 3 baryon system

- Few-body system physics
- Nuclear matter physics
- Neutron star physics
- ……

Its origin is unclear

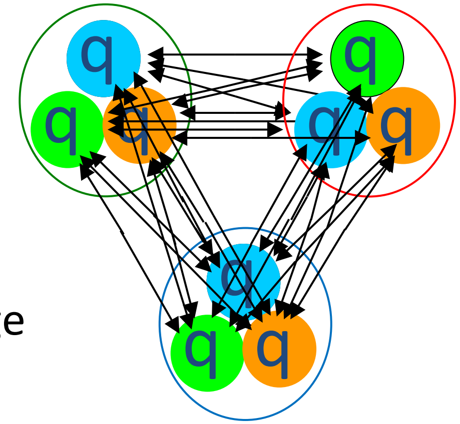
Theoretical approach

- 2π-exchange potential model (Fujita&Miyazawa)
- Phenomenological procedure
- Chiral effective-field theory
- Lattice QCD (HAL-QCD)
- ……

Approach by the quark model

9-quark 3-baryon system（3-cluster 9-body system）
⇒ appearance of the constituent effects

- Kinematical： quark-Pauli effect
- Dynamical： quark-quark interaction through quark-exchange



Quark-model approach to date

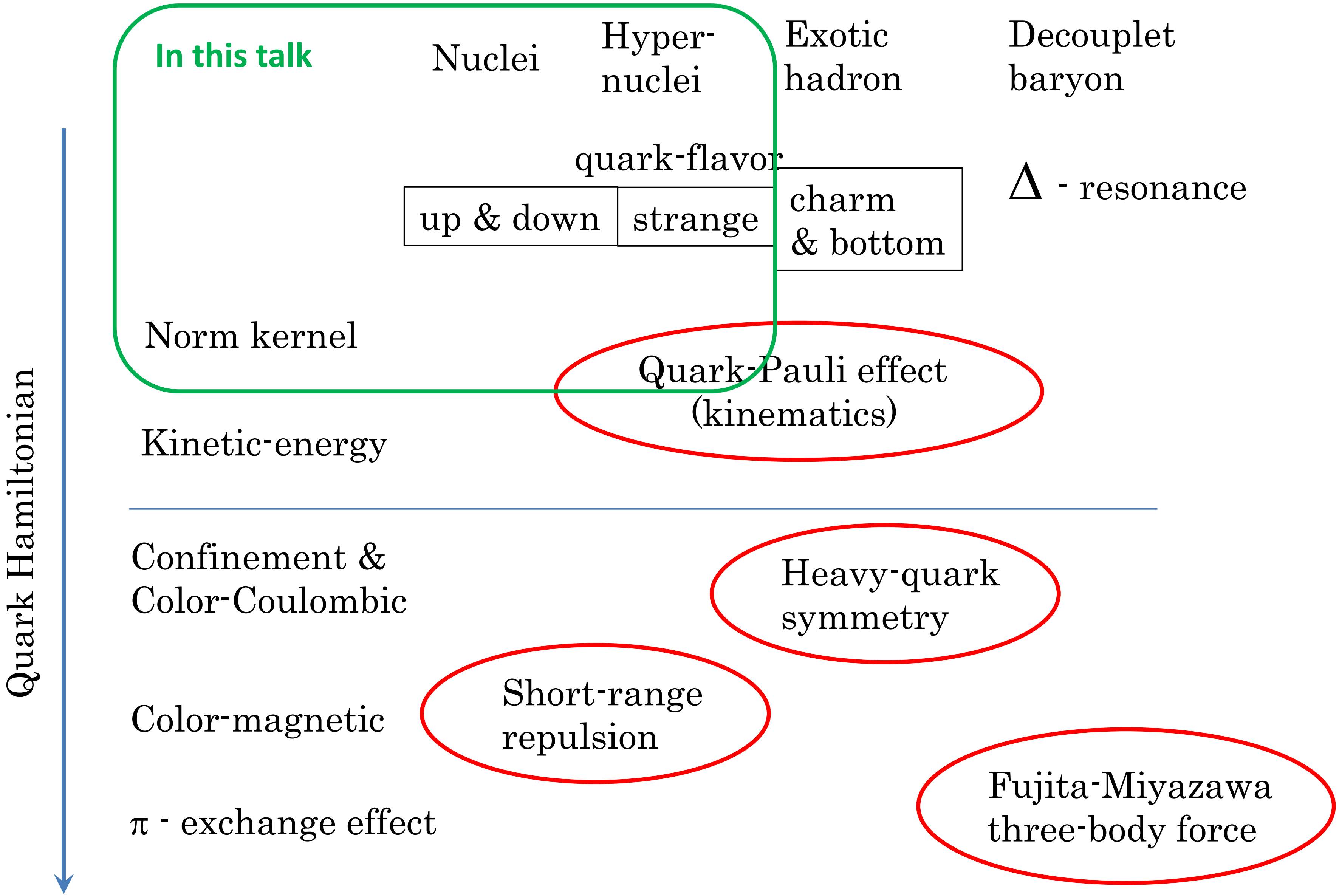
- Toki, Suzuki, Hecht：PRC26 (1982) 736
  Investigation of Pauli effect in the ^{3}He density through the NNN norm-kernel
- Suzuki, Hecht：PRC29 (1984) 1586
  Estimation of the Fermi-Breit interaction(OGEP) kernel in the NNN system
- Maltman：NPA439 (1985) 648
  Contribution to the charge form-factor of the FB-int. in the NNN & NNNN systems
- Takeuchi, Shimizu：PLB179 (1986) 197
  Estimation of the norm-kernel & kinetic-energy term in the ΛNN & ΛNNN systems

Advantage of quark-model

- Systematical research in the unified model-framework
  from 1-baryon to few-baryons
- Separate estimation of the Pauli effect, each interaction…

Our aim

- Understanding of 3-body baryon forces
  in the quark-model


In this talk
Nuclei
Hyper-nuclei
Exotic hadron
Decouplet baryon
quark-flavor
up & down
strange
charm & bottom
Δ - resonance
Norm kernel
Quark-Pauli effect (kinematics)
Kinetic-energy
Quark Hamiltonian
Confinement & Color-Coulombic
Heavy-quark symmetry
Short-range repulsion
Color-magnetic
Fujita-Miyazawa three-body force
π - exchange effect

Advantage of quark-model

- Systematical research in the unified model-framework
  from 1-baryon to few-baryons
- Separate estimation of the Pauli effect, each interaction…

Our aim

- Understanding of 3-body baryon forces
  in the quark-model

Present talk

Estimation of the quark-Pauli effect through the eigen-value
of the RGM norm-kernel in the $B_8B_8B_8$ systems

$\Rightarrow$ no parameter

2. Formulation

Resonating-group method (RGM) equation

2-baryon system

$$\int \left[\mathcal{H}(\vec{R'}_{12}, \vec{R}_{12}) - \varepsilon \mathcal{N}(\vec{R'}_{12}, \vec{R}_{12})\right] \chi(\vec{R}_{12})\, d\vec{R}_{12} = 0$$

RGM norm kernel

Relative wave-function between clusters

3-baryon system

$$\int\int \left[\mathcal{H}(\vec{R'}_{12}, \vec{R'}_{12-3}; \vec{R}_{12}, \vec{R}_{12-3}) - \varepsilon \mathcal{N}(\vec{R'}_{12}, \vec{R'}_{12-3}; \vec{R}_{12}, \vec{R}_{12-3})\right] \chi(\vec{R}_{12}, \vec{R}_{12-3})\, d\vec{R}_{12} d\vec{R}_{12-3} = 0$$

Eigen-value equation

2-baryon system

$$\int \mathcal{N}(\vec{R'}_{12}, \vec{R}_{12})\, \chi_k(\vec{R}_{12})\, d\vec{R}_{12} = \mu_k\, \chi_k(\vec{R'}_{12})$$

Eigen-value (μ_k)

3-baryon system

$$\int \mathcal{N}(\vec{R'}_{12}, \vec{R'}_{12-3}; \vec{R}_{12}, \vec{R}_{12-3})\, \chi_k(\vec{R}_{12}, \vec{R}_{12-3})\, d\vec{R}_{12} d\vec{R}_{12-3} = \mu_k\, \chi_k((\vec{R'}_{12}, \vec{R'}_{12-3})$$

$\mu_k = 0$: Pauli forbidden state

$\mu_k \sim 0$: almost Pauli forbidden state

Eigen-value

2-baryon system

$$\mu_{nl} = \int \psi_{nlm}(\vec{R'}_{12})^* \mathcal{N}(\vec{R'}_{12}, \vec{R}_{12}) \underline{\psi_{nlm}(\vec{R}_{12})}\, d\vec{R'}_{12}\, d\vec{R}_{12}$$

→ Harmonic-oscillator function

3-baryon system

$$\mu_{nl} = \int \Psi^{n'l'm'}_{(l'_1 l'_2)}(\vec{R'}_{12}, \vec{R'}_{12-3})^* \underline{\mathcal{N}(\vec{R'}_{12}, \vec{R'}_{12-3}; \vec{R}_{12}, \vec{R}_{12-3})} \Psi^{nlm}_{(l_1 l_2)}(\vec{R}_{12}, \vec{R}_{12-3})\, d\vec{R'}_{12}\, d\vec{R'}_{12-3}\, d\vec{R}_{12}\, d\vec{R}_{12-3}$$

⇓

We need only this RGM norm kernel

⇒ orbital part vanishes through the integral

⇒ We need only the factor for the color, spin and flavor parts

⇒ No parameter !

RGM normalization kernel

2-baryon system

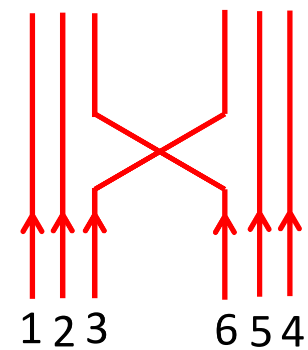
$$\mathcal{N}\left(\vec{R}',\vec{R}\right)=\frac{1}{2!}\left\langle \phi(1,2)_{S\,I}\,\delta(\vec{R}_{12}-\vec{R}')\,\middle|\,\mathcal{A}\,\middle|\,\phi(1,2)_{S\,I}\,\delta(\vec{R}_{12}-\vec{R})\right\rangle$$

Internal wave-function in the Baryon 1 & 2
(2-baryon system with the spin S and isospin I)

Antisymmetrizer $\mathcal{A}=(1-\mathcal{P})(1-9\,P_{36})$

baryon-exchange operator

quark -exchange operator



20 terms

3-baryon system

$$\mathcal{N}\left(\vec{R}'_a\,,\vec{R}'_b\,,\vec{R}_a\,,\vec{R}_b\right)$$

$$= \frac{1}{3!}\left\langle \phi(1,2,3)_{\frac{1}{2}I}\,\delta(\vec{R}_{12}-\vec{R}'_a)\delta(\vec{R}_{12-3}-\vec{R}'_b)\right|\mathcal{A}\left|\phi(1,2,3)_{\frac{1}{2}I}\,\delta(\vec{R}_{12}-\vec{R})\delta(\vec{R}_{12-3}-\vec{R}_b)\right\rangle$$

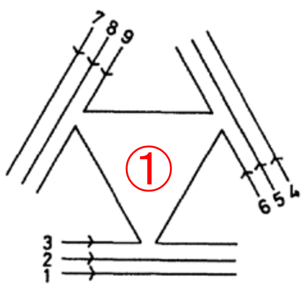
$$\mathcal{A} = [1 \quad \leftarrow \text{D-term}$$

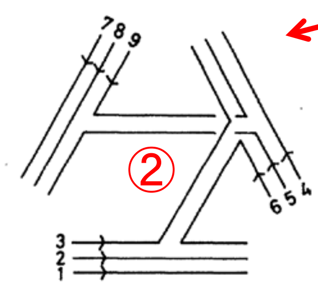
$$-9\,(P_{36}+P_{69}+P_{93}) \quad \leftarrow \text{2B-term}$$

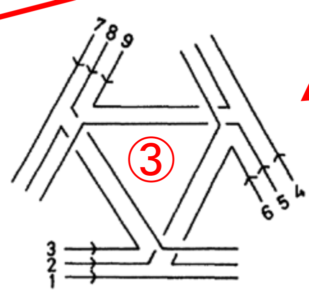
$$+27\,(P_{369}+P_{396})$$

$$+54\,(P_{36}P_{59}+P_{69}P_{83}+P_{93}P_{26})\,]\times\left[\sum_{\mathcal{P}=1}^{6}(-1)^{\pi(\mathcal{P})}\mathcal{P}\right]$$

$$-216\,P_{26}P_{59}P_{83}$$







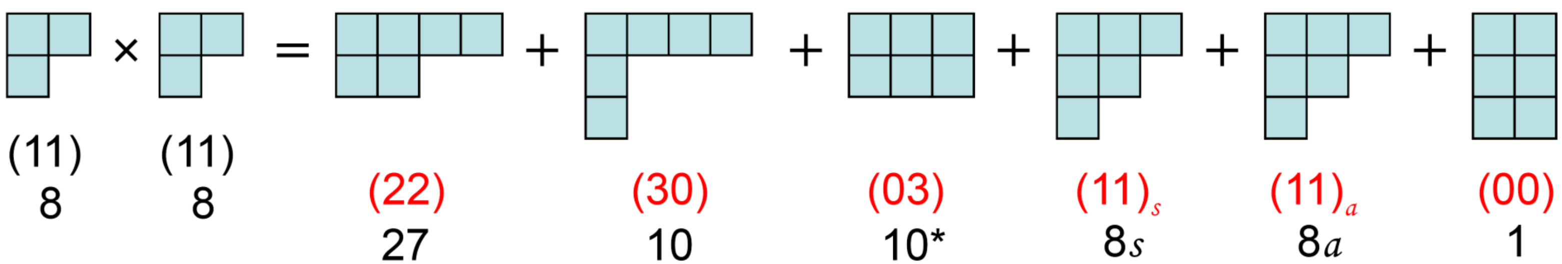
762 terms

3. Results

2-baryon system

Eigen-value components : (color) × (spin-flavor)

Two octet-baryon($B_8 B_8$) state



$$\dim(\lambda\mu) = \frac{1}{2}(\lambda+1)(\mu+1)(\lambda+\mu+2)$$

8 8 27 10 10* 8s 8a 1

B_8B_8 states : $(11) \times (11) = (22) + (30) + (03) + (11)_s + (11)_a + (00)$

Results

S	B_8B_8(isospin)	$\mathcal{P}=+1$(symmetric)	$\mathcal{P}=-1$(antisymmetric)	norm eigenvalue	
		^1E or ^3O	^3E or ^1O	^1S	^3S
0	$NN(0)$	–	(03)	–	$\frac{10}{9}$
	$NN(1)$	(22)	–	$\frac{10}{9}$	–
−1	ΛN	$\frac{1}{\sqrt{10}}[(11)_s+3(22)]$	$\frac{1}{\sqrt{2}}[-(11)_a+(03)]$	1	1
	$\Sigma N(\frac{1}{2})$	$\frac{1}{\sqrt{10}}[3(11)_s-(22)]$	$\frac{1}{\sqrt{2}}[(11)_a+(03)]$	$\frac{1}{9}$	1
	$\Sigma N(\frac{3}{2})$	(22)	(30)	$\frac{10}{9}$	$\frac{2}{9}$
−2	$\Lambda\Lambda$	$\frac{1}{\sqrt{5}}(11)_s+\frac{9}{2\sqrt{30}}(22)+\frac{1}{2\sqrt{2}}(00)$	–	1	–
	$\Xi N(0)$	$\frac{1}{\sqrt{5}}(11)_s-\sqrt{\frac{3}{10}}(22)+\frac{1}{\sqrt{2}}(00)$	$(11)_a$	$\frac{4}{3}$	$\frac{8}{9}$
	$\Xi N(1)$	$\sqrt{\frac{3}{5}}(11)_s+\sqrt{\frac{2}{5}}(22)$	$\frac{1}{\sqrt{3}}[-(11)_a+(30)+(03)]$	$\frac{4}{9}$	$\frac{20}{27}$
	$\Sigma\Lambda$	$-\sqrt{\frac{2}{5}}(11)_s+\sqrt{\frac{3}{5}}(22)$	$\frac{1}{\sqrt{2}}[(30)-(03)]$	$\frac{2}{3}$	$\frac{2}{3}$
	$\Sigma\Sigma(0)$	$\sqrt{\frac{3}{5}}(11)_s-\frac{1}{2\sqrt{10}}(22)-\sqrt{\frac{3}{8}}(00)$	–	$\frac{7}{9}$	–
	$\Sigma\Sigma(1)$	–	$\frac{1}{\sqrt{6}}[2(11)_a+(30)+(03)]$	–	$\frac{22}{27}$
	$\Sigma\Sigma(2)$	(22)	–	$\frac{10}{9}$	–
−3	$\Xi\Lambda$	$\frac{1}{\sqrt{10}}[(11)_s+3(22)]$	$\frac{1}{\sqrt{2}}[-(11)_a+(30)]$	1	$\frac{5}{9}$
	$\Xi\Sigma(\frac{1}{2})$	$\frac{1}{\sqrt{10}}[3(11)_s-(22)]$	$\frac{1}{\sqrt{2}}[(11)_a+(30)]$	$\frac{1}{9}$	$\frac{5}{9}$
	$\Xi\Sigma(\frac{3}{2})$	(22)	(03)	$\frac{10}{9}$	$\frac{10}{9}$
−4	$\Xi\Xi(0)$	–	(30)	–	$\frac{2}{9}$
	$\Xi\Xi(1)$	(22)	–	$\frac{10}{9}$	–

$$\begin{matrix} & & 8 & & 8 & & 27 & & 10 & & 10^* & & 8s & & 8a & & 1 \\ B_8B_8 \text{ states}: & & (11) & \times & (11) & = & (22) & + & (30) & + & (03) & + & (11)_s & + & (11)_a & + & (00) \end{matrix}$$

S	B_8B_8(isospin)	$\mathcal{P}=+1$(symmetric)	$\mathcal{P}=-1$(antisymmetric)	norm eigenvalue	
		^1E or ^3O	^3E or ^1O	^1S	^3S
0	$NN(0)$	–	(03)	–	$\frac{10}{9}$
	$NN(1)$	(22)	–	$\frac{10}{9}$	–
−1	ΛN	$\frac{1}{\sqrt{10}}[(11)_s+3(22)]$	$\frac{1}{\sqrt{2}}[-(11)_a+(03)]$	1	1
	$\Sigma N(\frac{1}{2})$	$\frac{1}{\sqrt{10}}[3(11)_s-(22)]$	$\frac{1}{\sqrt{2}}[(11)_a+(03)]$	$\frac{1}{9}$	1
	$\Sigma N(\frac{3}{2})$	(22)	(30)	$\frac{10}{9}$	$\frac{2}{9}$
−2	$\Lambda\Lambda$	$\frac{1}{\sqrt{5}}(11)_s+\frac{9}{2\sqrt{30}}(22)+\frac{1}{2\sqrt{2}}(00)$	–	1	–
	$\Xi N(0)$	$\frac{1}{\sqrt{5}}(11)_s-\sqrt{\frac{3}{10}}(22)+\frac{1}{\sqrt{2}}(00)$	$(11)_a$	$\frac{4}{3}$	$\frac{8}{9}$
	$\Xi N(1)$	$\sqrt{\frac{3}{5}}(11)_s+\sqrt{\frac{2}{5}}(22)$	$\frac{1}{\sqrt{3}}[-(11)_a+(30)+(03)]$	$\frac{4}{9}$	$\frac{20}{27}$
	$\Sigma\Lambda$	$-\sqrt{\frac{2}{5}}(11)_s+\sqrt{\frac{3}{5}}(22)$	$\frac{1}{\sqrt{2}}[(30)-(03)]$	$\frac{2}{3}$	$\frac{2}{3}$
	$\Sigma\Sigma(0)$	$\sqrt{\frac{3}{5}}(11)_s-\frac{1}{2\sqrt{10}}(22)-\sqrt{\frac{3}{8}}(00)$	–	$\frac{7}{9}$	–
	$\Sigma\Sigma(1)$	–	$\frac{1}{\sqrt{6}}[2(11)_a+(30)+(03)]$	–	$\frac{22}{27}$
	$\Sigma\Sigma(2)$	(22)	–	$\frac{10}{9}$	–
−3	$\Xi\Lambda$	$\frac{1}{\sqrt{10}}[(11)_s+3(22)]$	$\frac{1}{\sqrt{2}}[-(11)_a+(30)]$	1	$\frac{5}{9}$
	$\Xi\Sigma(\frac{1}{2})$	$\frac{1}{\sqrt{10}}[3(11)_s-(22)]$	$\frac{1}{\sqrt{2}}[(11)_a+(30)]$	$\frac{1}{9}$	$\frac{5}{9}$
	$\Xi\Sigma(\frac{3}{2})$	(22)	(03)	$\frac{10}{9}$	$\frac{10}{9}$
−4	$\Xi\Xi(0)$	–	(30)	–	$\frac{2}{9}$
	$\Xi\Xi(1)$	(22)	–	$\frac{10}{9}$	–

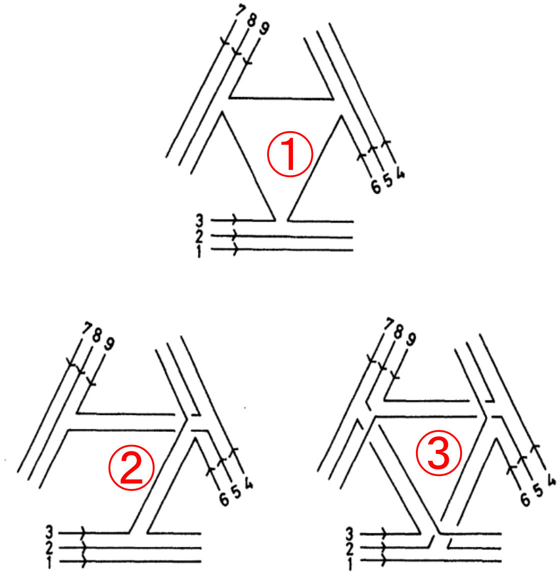
Origin of repulsive Σ nuclear potential

3-baryon system

Eigen-value components : (color) × (spin-flavor)

D−term	2B−term	①	②	③
1	$\frac{1}{3}$	$\frac{1}{9}$	$\frac{1}{9}$	0

We do not need to calculate ③-type



3-baryon system

Eigen-value components：(color) × (spin-flavor)

$B_8 B_8 B_8$ system

$$
\begin{aligned}
(22) \otimes (11) &= (41) \oplus (33) \oplus (30) \oplus (22)_s \oplus (22)_a \oplus (14) \oplus (11) \oplus (03) \\
(30) \otimes (11) &= (41) \oplus (30) \oplus (22) \oplus (11) \\
(03) \otimes (11) &= (22) \oplus (14) \oplus (11) \oplus (03) \\
(11) \otimes (11) &= (22) \oplus (30) \oplus (03) \oplus (11)_s \oplus (11)_a \oplus (00) \\
(00) \otimes (11) &= (11)
\end{aligned}
$$

$$\dim(\lambda\mu) = \frac{1}{2}(\lambda+1)(\mu+1)(\lambda+\mu+2)$$

Interesting $B_8B_8B_8$-systems

Triton $\left|NNN(I=\frac{1}{2})\right\rangle$

Hyper-triton
$|NN\Lambda(I=0)\rangle$
$|NN\Lambda(I=1)\rangle$

$nn\Lambda$

nnn $\left|NNN(I=\frac{3}{2})\right\rangle$

$nn\Sigma^-$ $|NN\Sigma(I=2)\rangle$

$nn\Xi^-$ $\left|NN\Xi(I=\frac{3}{2})\right\rangle$

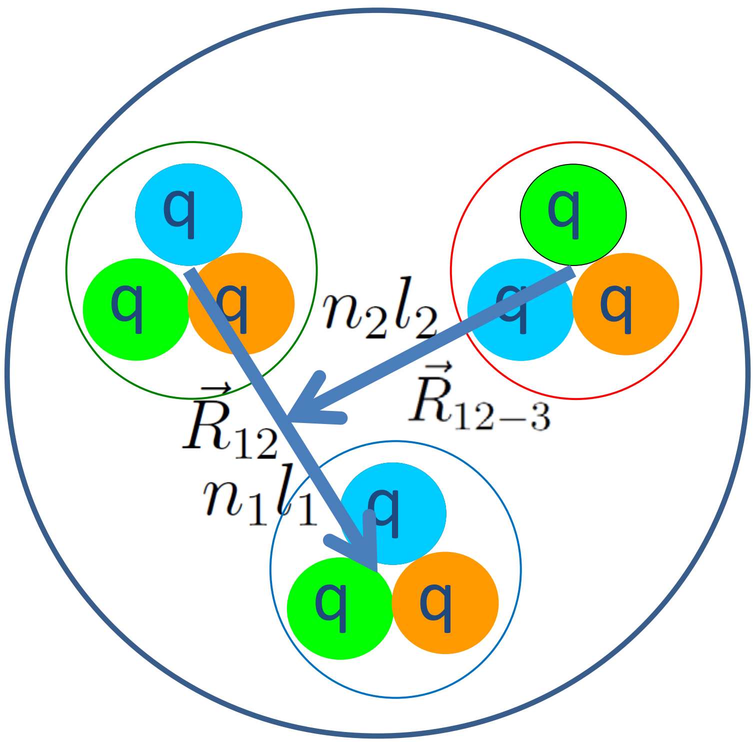
$\Lambda\Lambda\Lambda$ $|\Lambda\Lambda\Lambda\rangle$

$\Sigma^-\Sigma^-\Sigma^-$ $|\Sigma\Sigma\Sigma(I=3)\rangle$

$\Xi^-\Xi^-\Xi^-$ $\left|\Xi\Xi\Xi(I=\frac{3}{2})\right\rangle$

$\left|\Xi\Xi\Xi(I=\frac{1}{2})\right\rangle$

Eigenvalue for $B_8B_8B_8$



Total spin : S = ½

$(n\,l) = (00)$

Eigenvalue $\mu^{B_1 B_2 B_3}_{[SI(l_1 l_2)l]}$

$= (\text{D-term}) + (\text{2B-term}) + (\ ①\ ) + (\ ②\ )$

$(n_1 l_1) = (n_2 l_2) = \underline{(00)}$

Internal S-wave only

Interesting $B_8B_8B_8$-systems

Triton $\left|NNN(I=\frac{1}{2})\right\rangle$ =(14)

$\Lambda\Lambda\Lambda$ $|\Lambda\Lambda\Lambda\rangle$

$\Sigma^-\Sigma^-\Sigma^-$ $|\Sigma\Sigma\Sigma(I=3)\rangle$

Hyper-triton $|NN\Lambda(I=0)\rangle$, $|NN\Lambda(I=1)\rangle$

$\Xi^-\Xi^-\Xi^-$ $\left|\Xi\Xi\Xi(I=\frac{3}{2})\right\rangle$

$nn\Lambda$

nnn $\left|NNN(I=\frac{3}{2})\right\rangle$

$\left|\Xi\Xi\Xi(I=\frac{1}{2})\right\rangle$ =(41)

$nn\Sigma^-$ $|NN\Sigma(I=2)\rangle$

$nn\Xi^-$ $\left|NN\Xi(I=\frac{3}{2})\right\rangle$

$$\left|NNN(I=\tfrac{1}{2})\right\rangle \quad \& \quad \left|\Xi\Xi\Xi(I=\tfrac{1}{2})\right\rangle$$

Eigen-value components

(color) × (spin-flavor) × (orbital)

↓ NNN system

$$[[NN]_{I=1}N]_{I=\frac{3}{2}} = (33) \quad \Rightarrow \quad \left[[NN]_{(22)}N\right]_{I=\frac{3}{2}} = (33)$$

$$[[NN]_{I=1}N]_{I=\frac{1}{2}} = (14) \quad \Rightarrow \quad \left[[NN]_{(22)}N\right]_{I=\frac{1}{2}} = (14)$$

$$[[NN]_{I=0}N]_{I=\frac{1}{2}} = (14) \quad \Rightarrow \quad \left[[NN]_{(03)}N\right]_{I=\frac{1}{2}} = (14)$$

$$\left|NNN(I=\tfrac{1}{2})\right\rangle \quad \& \quad \left|\Xi\Xi\Xi(I=\tfrac{1}{2})\right\rangle$$

Eigen-value components

(color) × (spin-flavor) × (orbital)

ΞΞΞ system

$$[[\Xi\Xi]_{I=1}\,\Xi]_{I=\frac{3}{2}} = (33) \qquad \left[[\Xi\Xi]_{(22)}\,\Xi\right]_{I=\frac{3}{2}} = (33)$$

$$[[\Xi\Xi]_{I=1}\,\Xi]_{I=\frac{1}{2}} = (41) \qquad \left[[\Xi\Xi]_{(22)}\,\Xi\right]_{I=\frac{1}{2}} = (41)$$

$$[[\Xi\Xi]_{I=0}\,\Xi]_{I=\frac{1}{2}} = (41) \qquad \left[[\Xi\Xi]_{(30)}\,\Xi\right]_{I=\frac{1}{2}} = (41)$$

$$\left|NNN(I=\tfrac{1}{2})\right\rangle \quad \& \quad \left|\Xi\Xi\Xi(I=\tfrac{1}{2})\right\rangle$$

NNN system

$$\Big[[NN]_{(22)}\,N\Big]_{I=\frac{1}{2}} = (14)$$

$$\Big[[NN]_{\underline{(03)}}\,N\Big]_{I=\frac{1}{2}} = \underline{(14)}$$

10* 35*

ΞΞΞ system

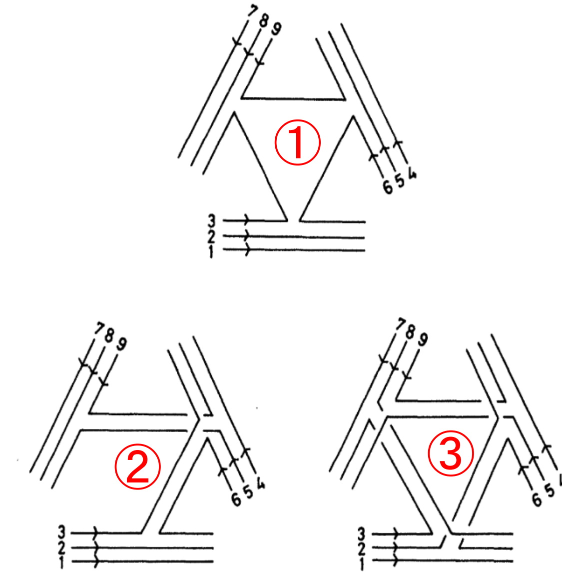
$$\Big[[\Xi\Xi]_{(22)}\,\Xi\Big]_{I=\frac{1}{2}} = (41)$$

$$\Big[[\Xi\Xi]_{\underline{(30)}}\,\Xi\Big]_{I=\frac{1}{2}} = \underline{(41)}$$

10 35

$$\left|NNN(I=\tfrac{1}{2})\right\rangle \quad \& \quad \left|\Xi\Xi\Xi(I=\tfrac{1}{2})\right\rangle$$

$\mu^{B_1B_2B_3}_{[SI(l_1l_2)l]}$		D−term	2B−term	①	②	Total
$\mu^{NNN}_{[\frac{1}{2}\frac{1}{2}(00)0]}$	NNN	1	$\frac{1}{3}$	$\frac{22}{81}$	$-\frac{30}{81}$	$\frac{100}{81}$
$\mu^{\Xi\Xi\Xi}_{[\frac{1}{2}\frac{1}{2}(00)0]}$	$\Xi\Xi\Xi$	1	-1	$-\frac{14}{81}$	$\frac{2}{9}$	$\frac{4}{81}$



- $\Xi\Xi\Xi$(SI=½½) state ⇒ strong Pauli-repulsion
- Quark-exchange contribution has opposite sign between NNN and $\Xi\Xi\Xi$ systems
- Quark-exchange contribution in the $3B_8$ system is 1/3-1/20 of it in the $2B_8$ system with opposite sign in this case

Interesting $B_8B_8B_8$-systems

Triton $\left|NNN(I=\frac{1}{2})\right\rangle$

Hyper-triton
- $|NN\Lambda(I=0)\rangle$
- $|NN\Lambda(I=1)\rangle$

$nn\Lambda$

nnn $\left|NNN(I=\frac{3}{2})\right\rangle$ $=(33)$

$nn\Sigma^-$ $|NN\Sigma(I=2)\rangle$

$nn\Xi^-$ $\left|NN\Xi(I=\frac{3}{2})\right\rangle$

$\Lambda\Lambda\Lambda$ $|\Lambda\Lambda\Lambda\rangle$

$\Sigma^-\Sigma^-\Sigma^-$ $|\Sigma\Sigma\Sigma(I=3)\rangle$ $=(33)$

$\Xi^-\Xi^-\Xi^-$ $\left|\Xi\Xi\Xi(I=\frac{3}{2})\right\rangle$ $=(33)$

$\left|\Xi\Xi\Xi(I=\frac{1}{2})\right\rangle$

Complete Pauli-forbidden states

nnn $\left|NNN(I=\frac{3}{2})\right\rangle$

$\Sigma^-\Sigma^-\Sigma^-$ $|\Sigma\Sigma\Sigma(I=3)\rangle$

$\Xi^-\Xi^-\Xi^-$ $\left|\Xi\Xi\Xi(I=\frac{3}{2})\right\rangle$

$= (33)$ 64

$$|\Lambda\Lambda\Lambda\rangle = \sqrt{\frac{540}{1400}}\underset{64}{(33)} + \sqrt{\frac{216}{1400}}\underset{27s}{(22)_s} + \sqrt{\frac{189}{1400}}\underset{27}{(22)}$$

$$+\sqrt{\frac{56}{1400}}\underset{8s}{(11)_s}+\sqrt{\frac{189}{1400}}\underset{8}{(11)_{(22)}}+\sqrt{\frac{175}{1400}}\underset{8}{(11)_{(00)}}+\sqrt{\frac{35}{1400}}\underset{1}{(00)}$$

derived from $27 \otimes 8$ derived from $1 \otimes 8$

All eigen-value in internal S-wave are 0

$\langle\Lambda\Lambda\Lambda|\mathcal{A}|\Lambda\Lambda\Lambda\rangle = 0$ → Check of calculation : OK!

Interesting $B_8B_8B_8$-systems

Triton $\left|NNN(I=\frac{1}{2})\right\rangle$

Hyper-triton
- $|NN\Lambda(I=0)\rangle$
- $|NN\Lambda(I=1)\rangle$

$nn\Lambda$

nnn $\left|NNN(I=\frac{3}{2})\right\rangle$

$nn\Sigma^-$ $|NN\Sigma(I=2)\rangle$

$nn\Xi^-$ $\left|NN\Xi(I=\frac{3}{2})\right\rangle$

$\Lambda\Lambda\Lambda$ $|\Lambda\Lambda\Lambda\rangle$

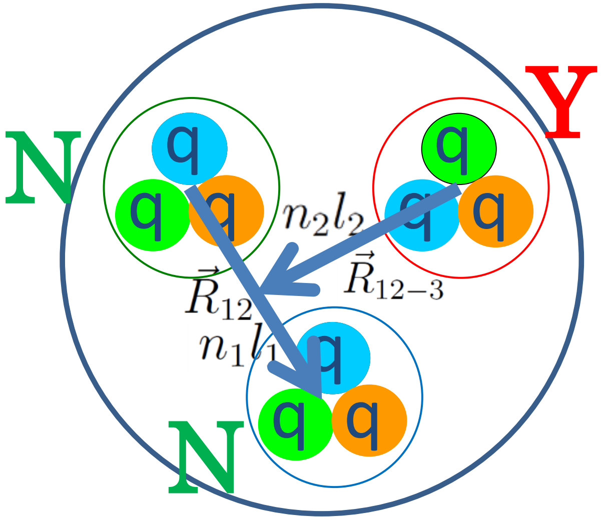
$\Sigma^-\Sigma^-\Sigma^-$ $|\Sigma\Sigma\Sigma(I=3)\rangle$

$\Xi^-\Xi^-\Xi^-$ $\left|\Xi\Xi\Xi(I=\frac{3}{2})\right\rangle$

$\left|\Xi\Xi\Xi(I=\frac{1}{2})\right\rangle$

NNY systems

In this case,
we consider as Pauli effect
the ratio of the eigen-value to D-term.



$$|NN\Lambda(I=0)\rangle = \sqrt{\tfrac{1}{2}}\,[(14)+(03)]$$

$$|NN\Lambda(I=1)\rangle = \sqrt{\tfrac{16}{56}}(33) + \sqrt{\tfrac{5}{56}}(22)_s + \sqrt{\tfrac{21}{56}}(22)_a - \sqrt{\tfrac{14}{56}}(14)$$

$$|NN\Sigma(I=2)\rangle = -\sqrt{\tfrac{2}{3}}(41) + \sqrt{\tfrac{1}{3}}(33)$$

$$\left|NN\Xi(I=\tfrac{3}{2})\right\rangle = -\sqrt{\tfrac{70}{504}}(41) + \sqrt{\tfrac{40}{504}}(33) - \sqrt{\tfrac{140}{504}}(30) + \sqrt{\tfrac{135}{504}}(22)_s + \sqrt{\tfrac{63}{504}}(22)_a - \sqrt{\tfrac{56}{504}}(14)$$

NNY systems

I must apologize for changing the eigen-value in this NNY systems and thereby conclusion also.

cf. : $\mu^{NNN}_{[\frac{1}{2}\frac{1}{2}(00)0]} = \frac{100}{81}$

relatively

$$\mu^{NN\Lambda}_{[\frac{1}{2}1(00)0]} = \mu^{NN\Lambda}_{[\frac{1}{2}0(00)0]} = \frac{25}{27}$$

moderate

$nn\Lambda$

relatively

$$\mu^{NN\Sigma}_{[\frac{1}{2}2(00)0]} = \frac{4}{81}$$

$nn\Sigma^-$

Strongly repulsive

relatively

$$\mu^{NN\Xi}_{[\frac{1}{2}\frac{3}{2}(00)0]} = \frac{10}{27}$$

$nn\Xi^-$

repulsive

We have to investigate YN-N configuration also
in order to get more information about the quark-Pauli effect.

4. Summary

- We investigated the quark-Pauli effects by evaluating the RGM normalization kernel for the $B_8B_8B_8$ systems. (no parameter)
- Strong ordering of quark-Pauli repulsion :

$$nn\Sigma^- = \Xi\Xi\Xi(1/2) > nn\Xi^- > nn\Lambda = \mathrm{NN}\Lambda(0) > \mathrm{NNN}(1/2)$$

- In order to get more information about the quark-Pauli effect of NNY system, we need to investigate YN-N configuration also.

Future

- About YN-N configuration
- Total spin 3/2 case
- Contribution to total S-state from internal P-wave between 2-baryon

- Estimation of the kinetic-energy term
- Estimation of the interaction term
- including decouplet baryon…