ρ_B $\quad A \quad \times A \quad T = 0$

$$k_F \sim (3\pi^2 \rho_B)^{1/3}$$

$\rho_B = \rho_0 \qquad T_F = \dfrac{k_F^2}{2m} \sim 25\ \text{MeV} \sim 10^{11}\ \text{K}$

$$T \sim 10^{9} \div 10^{10}$$

$$P = P(n_B) \Rightarrow e = \frac{E(n_B)}{N_B}$$

$$P = -\left(\frac{\partial E}{\partial V}\right)_{N_B} = n_B^2 \frac{\partial e}{\partial n_B}$$

$$\boxed{e(n_B)}$$

$$H = \sum_{i=1}^{N_B} \frac{p_i^2}{2m} + \sum_{j>i=1}^{N_B} v_{ij} + \dots$$

- $\dfrac{B}{A} \sim \text{const} \qquad A > 16 \Rightarrow v(r > r_0) \sim 0$

- $\rho_{ch}(r \simeq 0) \sim$ independent of A

$v(r < r_c) \gg 0$

1957 Yukawa $\quad r_0 \sim 10^{-13}\ \text{cm} = 1\ \text{fm}$

$\mu \sim r_0^{-1} \sim 200$ MeV

$m \simeq r_0 \approx 200$ MeV

Pione

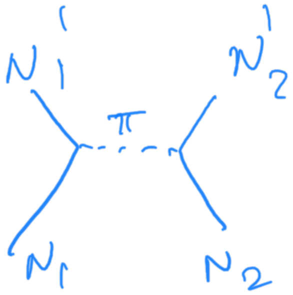
$m_\pi \sim 140$ MeV $\qquad \pi^0 \quad \pi^\pm \qquad J^+ = 0^-$

$$\mathcal{L} = \bar{\psi}(i\not{\partial} - m)\psi + \boxed{ig\bar{\psi}\gamma^5 \vec{\tau}\psi\vec{\pi}}$$

$$\psi = \begin{pmatrix} p \\ n \end{pmatrix} \qquad \pi = \begin{pmatrix} \pi_1 \\ \pi_2 \\ \pi_0 \end{pmatrix} \qquad \pi_1 = \frac{1}{\sqrt{2}}(\pi^+ + i\pi^-)$$

$\dots$

$\pi_3 = \pi^0$



$\sim \quad \langle N_1' N_2' | V | N_1 N_2 \rangle$

$$V \sim \frac{e^{-m_\pi r}}{r}$$

$N_1 + N_2 \to N_1' + N_2'$

$$\alpha \sim \frac{e^2}{4\pi} \sim \frac{1}{137} \qquad \frac{g^2}{4\pi} \approx 14$$

$^2H \qquad \underbrace{pn} \qquad p : |\uparrow\rangle \qquad n : |\downarrow\rangle$

$|pp\rangle = |\uparrow\uparrow\rangle \qquad |nn\rangle = |\downarrow\downarrow\rangle$

$T = 1 \qquad\qquad T = 1$

$$\Rightarrow \boxed{T = 1 \quad \frac{1}{\sqrt{2}}(|pn\rangle + |np\rangle)} \Leftarrow$$

$$T = 0 \quad \frac{1}{\sqrt{2}}(|pn\rangle - |np\rangle)$$

$S=1$ $\quad\quad$ $T=0 \; S=1$

$$E_d = (m_p + m_p - M_D) \simeq 2.2 \text{ MeV}$$

$$\frac{E_d}{M_D} \sim 10^{-3}$$

$$\sum_{ST} v_{ST}(r)\, \tilde{P}_T\, P_S = \sum_{i=1}^{4} \underline{v^{(i)}(r)\, O^{(i)}_{1}}$$

$$P_{S=0} = \frac{1}{4}\left[1 - (\vec{\sigma}_1 \cdot \vec{\sigma}_2)\right]$$

$$P_{S=1} = \frac{1}{4}\left[3 + (\vec{\sigma}_1 \cdot \vec{\sigma}_2)\right]$$

$$Q_D \neq 0$$

$$\sum_{i=5}^{6} v^{(i)}(r_{12})\, O^{(i)}_{12}$$

$$O^{(5)}_{12} = \frac{3}{r_{12}^2}(\vec{\sigma}_1 \vec{r}_{12})(\vec{\sigma}_2 \vec{r}_{12}) - (\vec{\sigma}_1 \vec{\sigma}_2)$$

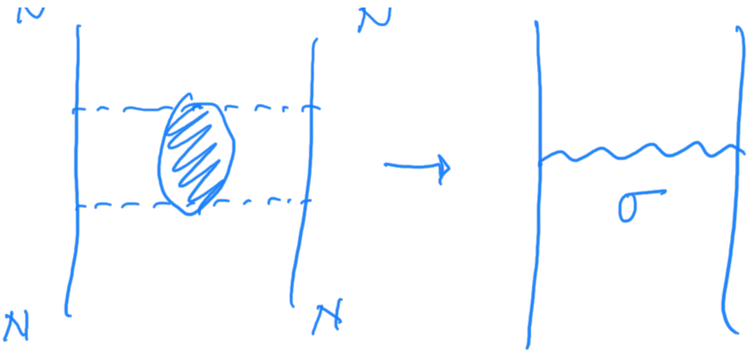
$$O^{(6)}_{12} = O^{(5)}_{12}(\vec{\tau}_1 \vec{\tau}_2)$$

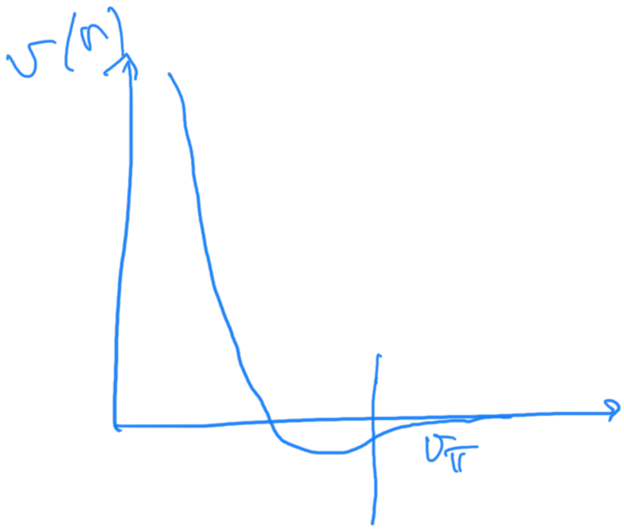
$$S=0 \quad O^{(5)}_{12} = 0$$

$$v_{12} = \sum_{i=1}^{6} v^{(i)}(r_{12})\, O^{(i)}_{12}$$

$$\pi$$

$$v(r_{12}) \xrightarrow[r_{12}\to\infty]{} v_{OPE}(r_{12})$$





Argonne v_{18}

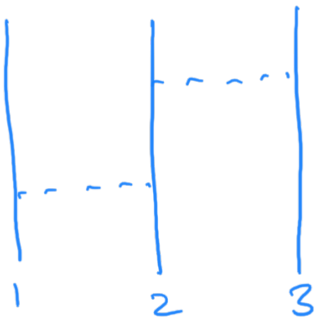
$$\sum_{i=1}^{18} v^{(i)}(r_{12})\, O_{12}^{(i)}$$

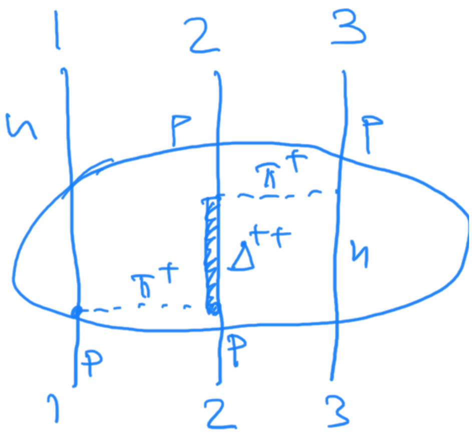
P $\quad i = 7, 8 \quad (\vec{l}\cdot\vec{s})\,[1, (\vec{\tau}_1\vec{\tau}_2)]$

$i = 8, 14 \quad L^2\,[1, (\vec{\tau}_1\vec{\tau}_2)] \quad (l\,s)^2\,[1, (\vec{\tau}_1\vec{\tau}_2)]$

$\sim \ldots$

$i = 15, 18$ charge-symmetry breaking





$\uparrow\uparrow\downarrow$

$$p + \pi^+ \to \Delta^{++} \to p + \pi^+$$

$$H = \underbrace{\sum \frac{p^2}{2m} + \sum v_{ij}}_{H_0} \boxed{+ \sum V_{ijk}}$$

$A = 2$

$A = 3$

$$H_0 |\Psi_{^3He}\rangle = E_0 |\Psi_{^3He}\rangle$$

$$|E_0| \leq |E_3|$$