write down V_{3N} 3N forces c_i, D, E from $\mathcal{L}^{(1)}$

Sources of difference in the c_i extractions

- finite-order extraction → truncation error $\frac{Q}{\Lambda_b}$ → see N^3LO 3N forces (for 3N)
- πN vs. NN: different kinematics — πN: pion on-shell $E \geq m_\pi$; NN: pion virtual

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shorter-range N^2LO 3N forces

$$V_{3N,\pi}^{(3)} = \sum_{i\neq j\neq k} \left(-D\frac{g_A}{8f_\pi^2}\right) \frac{\vec{\sigma}_j\cdot\vec{q}_j\ \vec{\sigma}_i\cdot\vec{q}_j}{q_j^2+m_\pi^2}\ \vec{\tau}_i\cdot\vec{\tau}_j$$

$$V_{3N,\text{contact}}^{(3)} = \sum_{i\neq j\neq k} \frac{E}{2}\ \vec{\tau}_j\cdot\vec{\tau}_k$$

convention: dimensionless coupling $c_D = D f_\pi^2 \Lambda_\chi$ with $\Lambda_\chi = 700$ MeV (choice) — dimensionful cutoff scale

$c_E = E f_\pi^4 \Lambda_\chi$

N^2LO 3N forces only have 2 LECs: c_D, c_E → fit to A=3,4 Q: Why light nuclei?

usually fit to $B(^3H)$ + a_{n-d}

or " + $r(^4He)$

or " + ^3H β-decay half-life → see Thursday

→ predict structure + scatter/reactions to N^2LO (NN+3N)

majority of calculations with N^3LO NN + N^2LO 3N because full N^3LO 3N forces only derived recently

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N^3LO 3N forces: Q^4, no new contact interactions! → parameter free

→ 3N topologies

N^3LO 4N forces: Q^4, all vertices $\Delta_i = 0$ (no cancellation like for NLO 3N)

also parameter-free

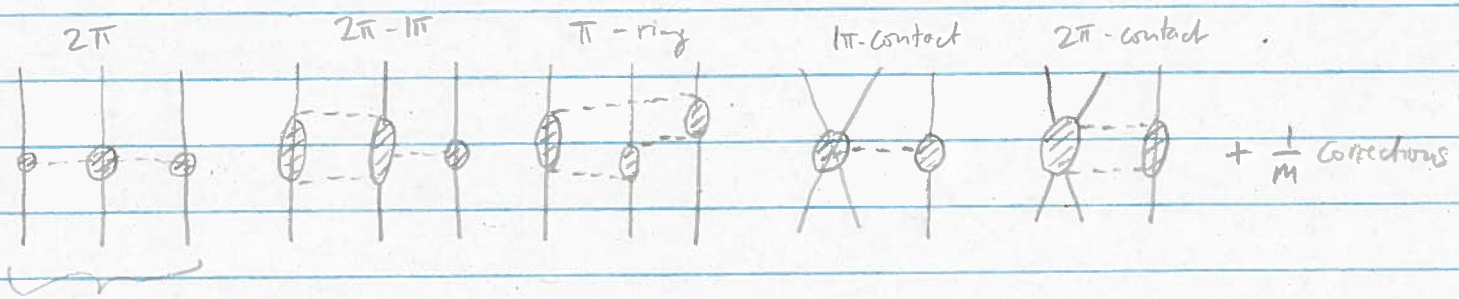
4N contact only at N^5LO (Q^6)

$\nu = -4 + 2\cdot 4 + 0 + \Delta_i = 6$

$\Delta_i = 0 + \frac{8}{2} - 2$

N^3LO 3N topologies

one-loop contributions $\nu = -4 + 2N + 2L + \sum_i \Delta_i$ all $\Delta_i = 0 \Rightarrow \nu = 4$ and $L = 1$



operators like N^2LO 3N + small rest

$$\delta c_1 = -\frac{g_A^2 m_\pi}{64\pi f_\pi^2} \qquad \delta c_3 = -\delta c_4 = \frac{g_A^4 m_\pi}{16\pi f_\pi^2}$$