$\boxed{\text{March 31}}$

Chiral hamiltonians

Start from an effective lagrangian involving pions and nucleons, constrained by the broken chiral symmetry of strong interaction

Infinite number of terms

$$\mathcal{L} = \mathcal{L}^{(0)} + \left(\frac{Q}{\Lambda_b}\right)^2 \mathcal{L}^{(2)} + \left(\frac{Q}{\Lambda_b}\right)^3 \mathcal{L}^{(3)} + \ldots$$

$\boxed{\Lambda_b \sim 800 \text{ MeV}}$

\# Main advantages:

- systematic scheme
- two- and many-nucleon forces derived within

a consistent framework

Drawbacks:

- Cutoff dependence
- Momentum expansion

In degenerate neutron matter

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

neutron - neutron collision can only involve momenta $\sim k_F$ (Pauli blocking) $\Rightarrow$ energy

$$E_{lab} = 2 E_{cm}$$

$$= \frac{2}{m} (3\pi^2 \rho_B)^{2/3}$$

ability to describe phase shifts $\Longleftrightarrow$ ability to describe dense matter

(see figure 8)

Conclusion: chiral interactions provide a viable alternative to purely phenomenological Hamiltonians, but cannot reliably used @ densities larger than $1 - 2\,\rho_0$ $(\rho_0 = 0.16\ \mathrm{fm}^{-3} \simeq 2.7\ 10^{14}\ \mathrm{g\,cm}^{-3})$

$\#\!\!\!\!\!=$

Many-body theory

$$H = T + V + U$$

Even the simplest problem: solving

$$H|\Psi_0\rangle = E_0|\Psi_0\rangle$$

involves prohibitive computational difficulties for $A > 4$.

Structure of $|\Psi_0\rangle$ involves strong spin-isospin dependence

\# of spin isospin configurations

$^4He \sim 10^2$

$^{12}C \sim 10^6$

- Brute force solution using stochastic methods
- Approximate solutions
  - perturbation theory made difficult by strong range repulsio[n]

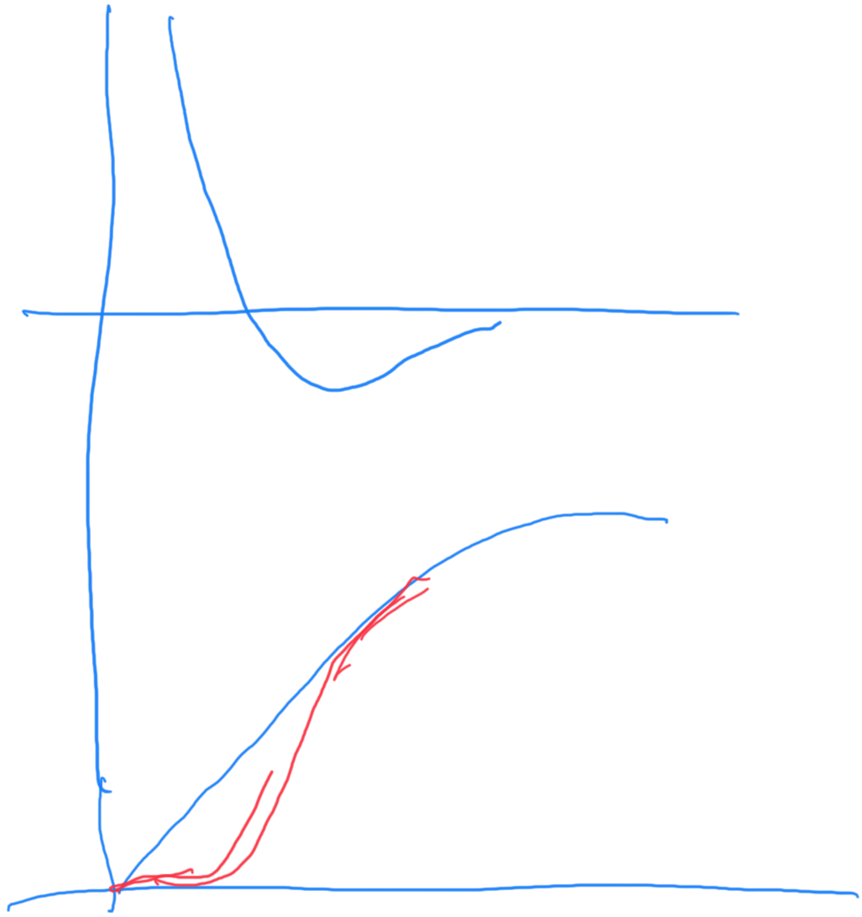
    Consider a nucleon pair in uniform matter

$$\psi_0 \sim \frac{\sin(kr)}{kr}$$

First-order perturbation theory

$$\Delta E \sim \langle \psi_0 | V | \psi_0 \rangle$$

large



G matrix → convergence

Q-MC · Three-nucleon forces

Variational
↳ accuracy.

Quantum Monte Carlo

Imaginary time Schrödinger equation

$$-\frac{\partial \Psi_0}{\partial \tau} = H \Psi_0$$

$$\Psi(X,\tau) = \int dX' \, G(X,X',\tau) \, \Psi(X',\tau)$$

$$G(X,X',\tau) = \langle X | e^{-H\tau} | X \rangle$$

Trial wave function

$$|\tilde{\Psi}_0\rangle = \sum_n c_n |\Psi_n\rangle$$

$$|\Psi(0)\rangle = |\tilde{\Psi}_0\rangle$$

$$\lim |\Psi(\tau)\rangle \ldots$$

$$\tau \to \infty$$

$$= \lim_{\tau \to \infty} e^{-(E_0 - \mu)\tau} \, a_0 |\Psi_0\rangle .$$

QMC possible for pure neutron matter (64 neutrons in a box)

- Isospin-Symmetric matter still involves uncertainties.