Nonlocal potential obtained from a quark model in hypernuclei

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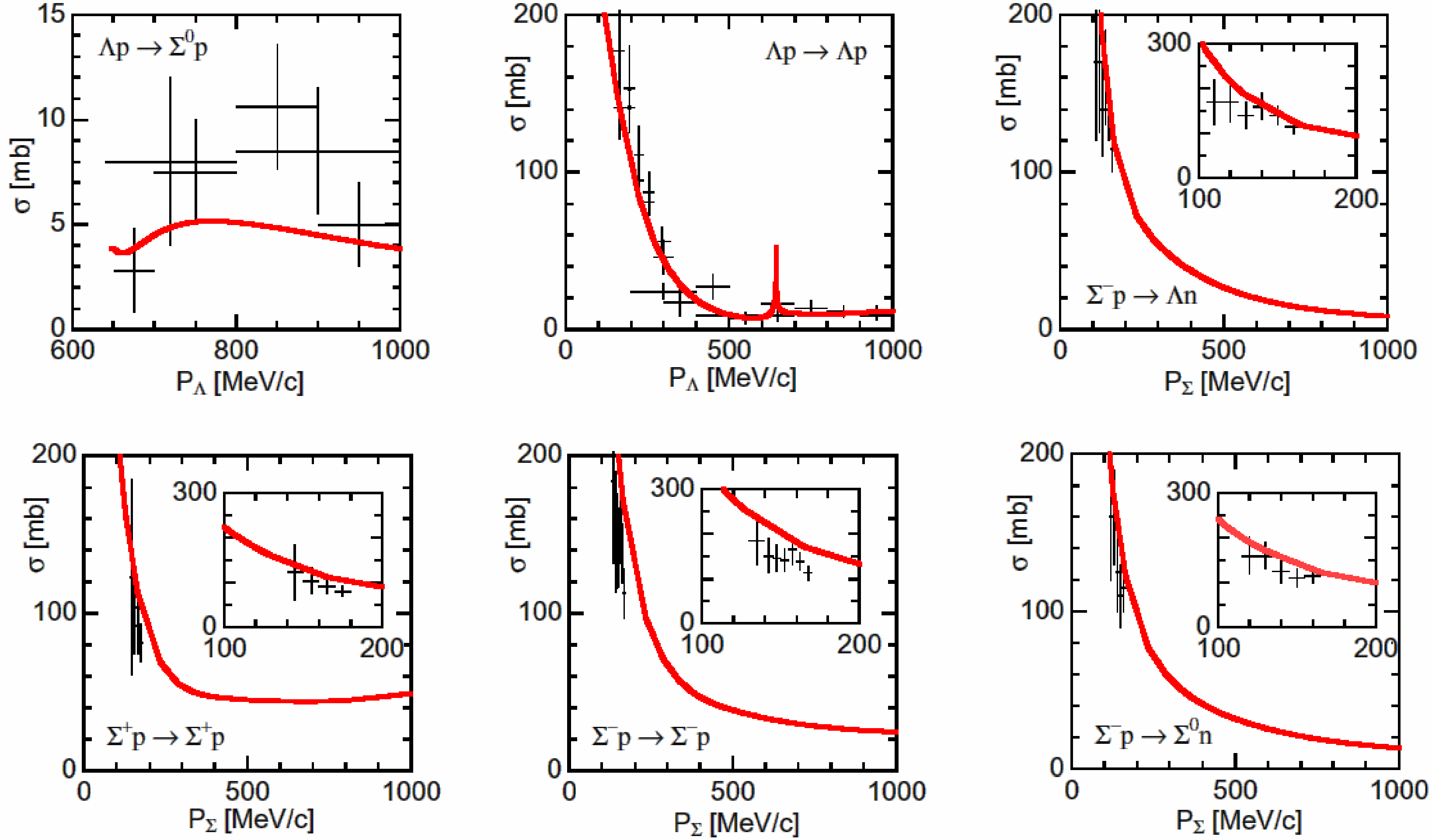
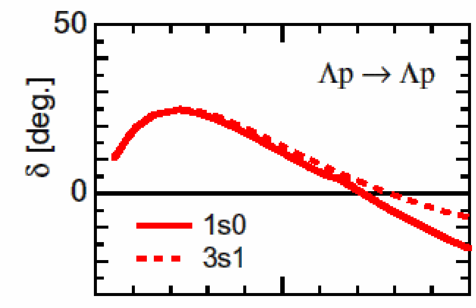
- ✓ Construct a QCM potential
  (energy-*in*dependent *nonlocal* potential)
- ✓ Construct an on-shell equiv *local* potential
- ✓ To investigate the effect of nonlocality, compare the two potentials by looking into their G-matrices.
- ✓ $^4_\Sigma$He.
  - ◊ Use of the nonlocal potential is essential in strong Pauli-blocking channels.
  - ◊ Local approximation is good in weak Pauli-blocking channels

S. Takeuchi and K. Shimizu, Phys. Rev. **C 65** 064006(2002); Nucl. Phys. **A723** 408(2003).





YN cross section given by QCM

Def of QCM two baryon potential

Schrödinger eq for 6 quarks: $H_q = K_q + V_q$

can be reduces into the RGM equation,

$$\int dR' \left(H_{RGM}(R,R') - E\,N(R,R') \right) \chi(R') = 0 \,,$$

which can be rewritten in Shrödinger-like eq:

$$\left(\overline{H} - E \right) \overline{\chi} = 0$$

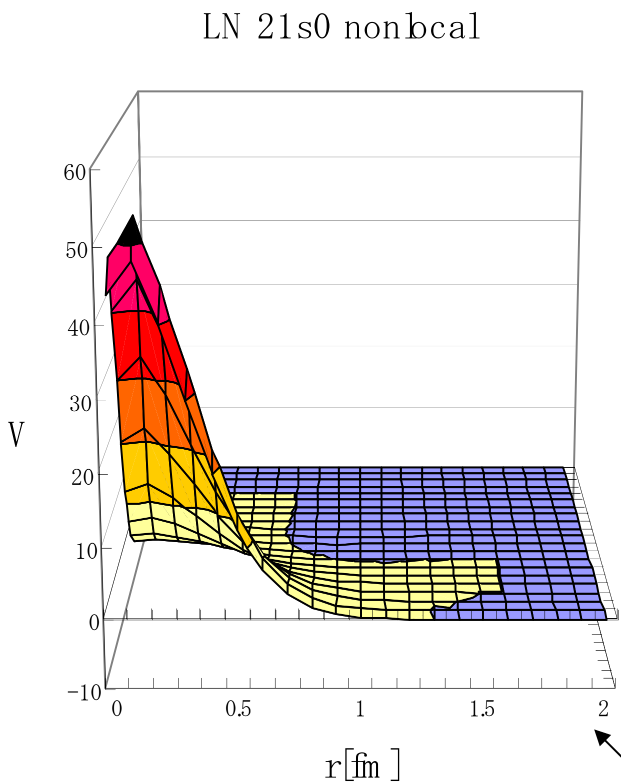
with $\overline{H} = N^{-1/2}\, H\, N^{-1/2}$ $\quad \overline{\chi} = N^{1/2}\, \chi$.

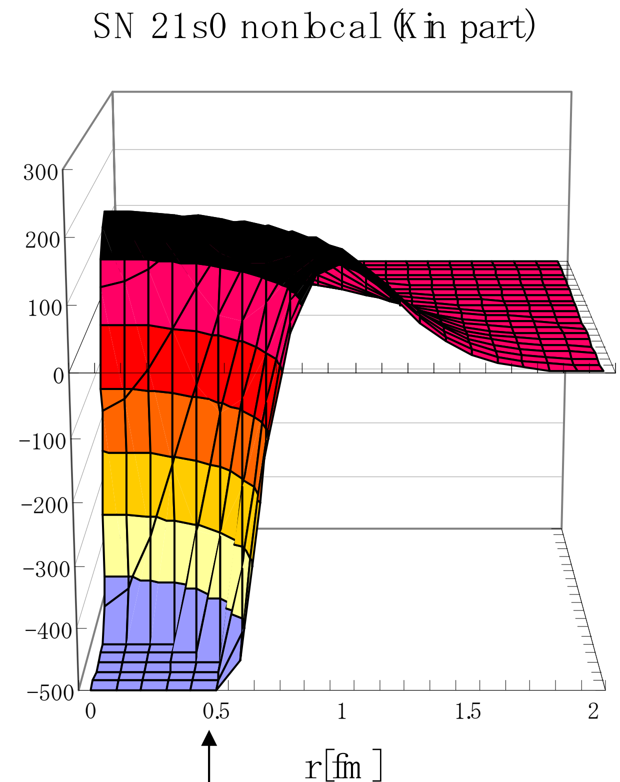
QCM potential can be defined by:

$V_{QCM} = \overline{H} - K_0$, which is Energy-independent and nonlocal potential.

Features of QCM baryon potential

- Vqcm= Vlocal + Vnonlocal

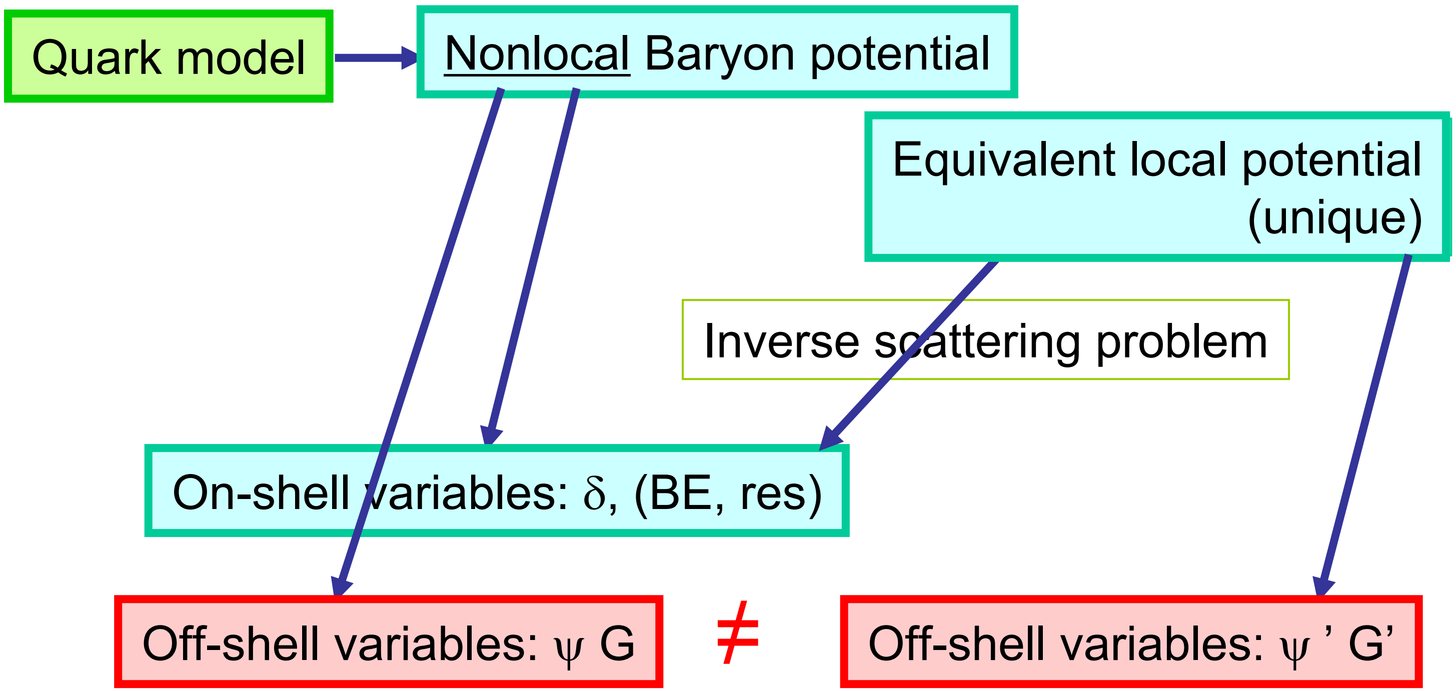




Channel where quark Pauli-blocking is Weak. Strong

Nonlocality can be seen as off-shell effects

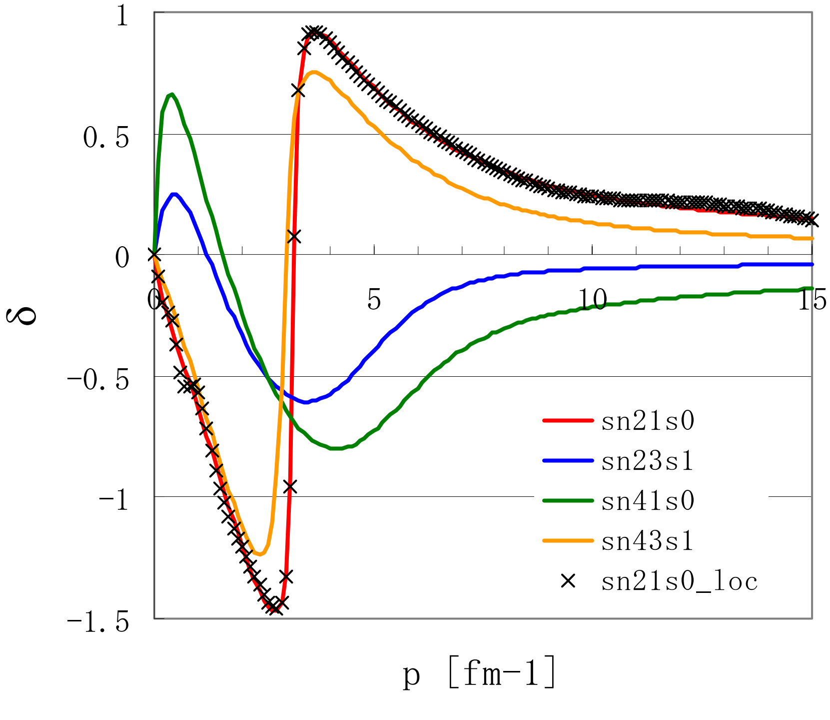
how to identify the effect of nonlocality



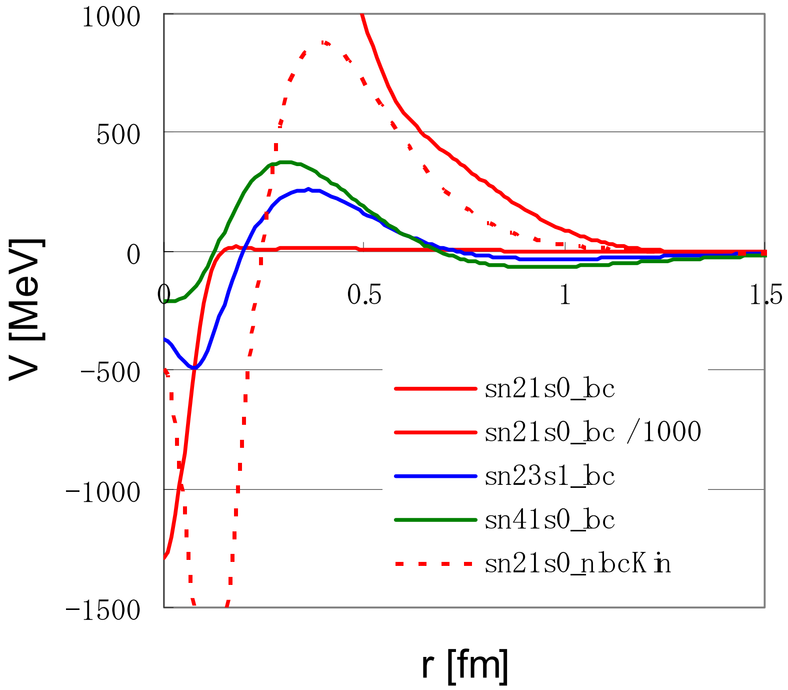
Size of the difference corresponds to the effect of nonlocality

Examples of On-shell Equiv Local Potentials

- phase shifts



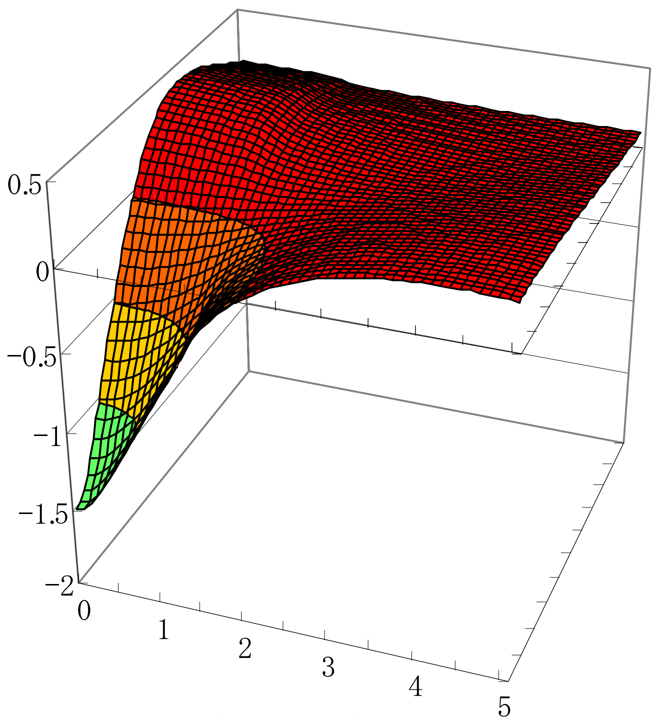
- Equivalent local potentials
  - quark Pauli-blocking is large
    -> Local potential is large



G-matrices -- Weak Pauli-blocking channel

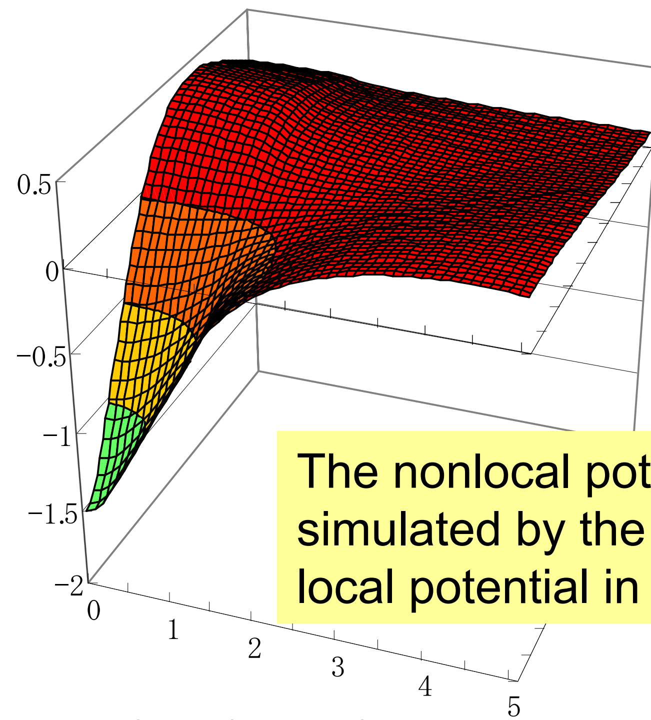
- G-matrix by the original QCM potential

$\Sigma N^{41}s_0$



- G-matrix by the equivalent local potential

$\Sigma N^{41}s_0$

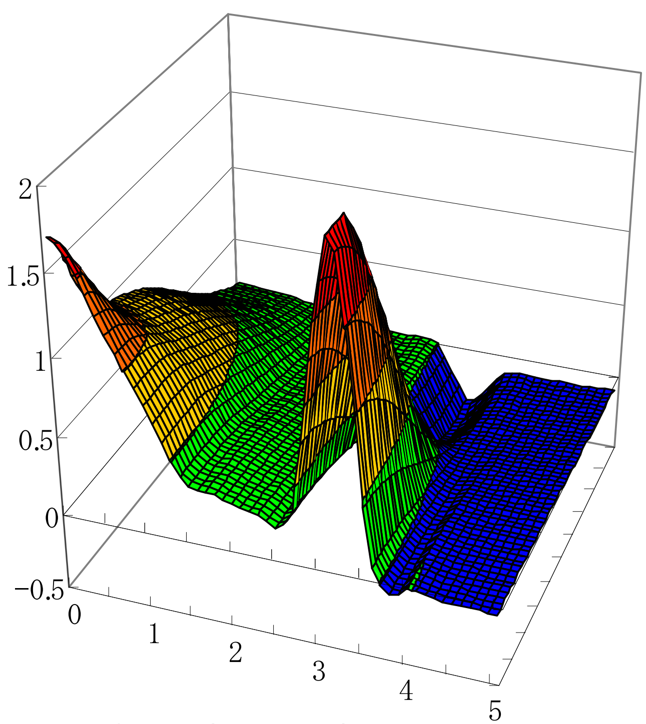


The nonlocal potential can be simulated by the equivalent local potential in this channel.

G-matrices -- Strong Pauli-blocking channel

- G-matrix by the original QCM potential

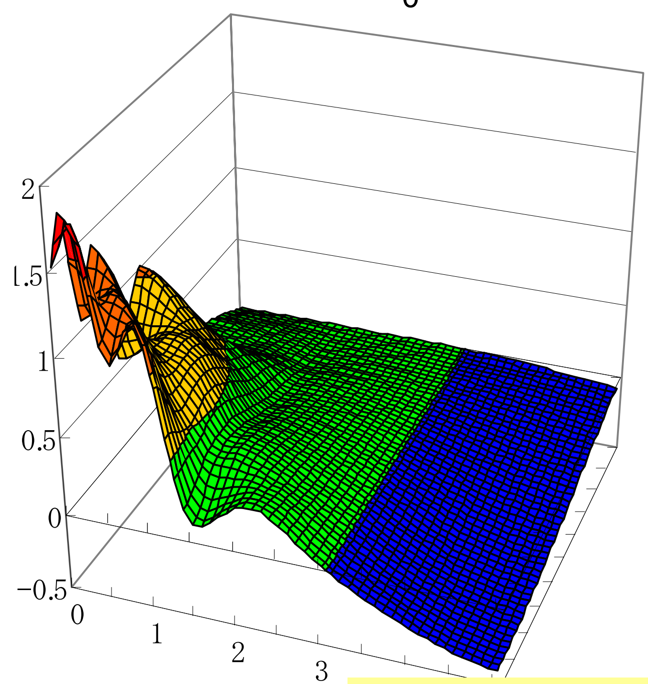
$\Sigma N^{21}s_0$



p [fm-1] (on-shell)

- G-matrix by the equivalent local potential

$\Sigma N^{21}s_0$

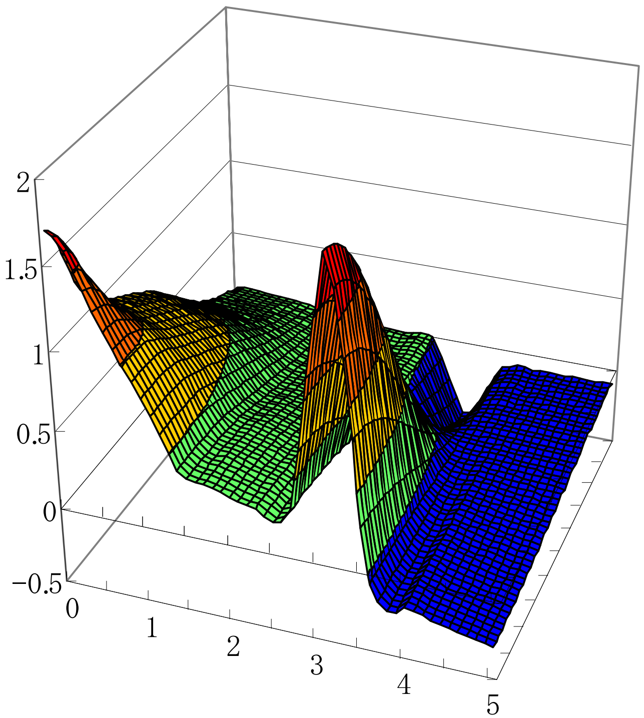


p [fm-1] (on-shell)

The nonlocal potential can *not* be simulated by the equivalent local potential in this channel.

Keep nonlocality in the Kinetic term

When the kinetic term is kept nonlocal



p [fm-1] (on-shell)

- Potential has a form:

$$V_{knloc}=V_K+V_{local}$$

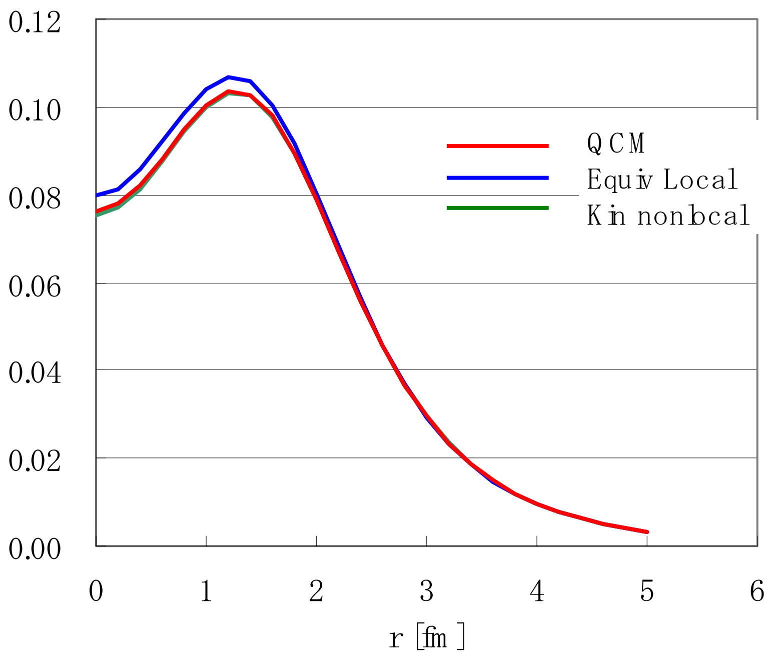
G-matrices are well-simulated by considering nonlocality in the kinetic term, even for the channels where the quark Pauli-blocking is large.

${}^{4}_{\Sigma}$He

- Applied to ${}^{4}_{\Sigma}$He

QCM	1.24MeV
Equiv local	1.36MeV
Kin-nonlocal	1.26MeV

Density



Nonlocal effect is rather small

because the wave function is

$$\frac{4}{9}\ {}^{41}S_0 + \frac{1}{2}\ {}^{23}S_1 + \boxed{\frac{1}{18}\ {}^{21}S_0}$$

how about ${}^{43}S_1$?

because the channel is repulsive

how about ΞN?

Comment on the Σ-mixture

- Quark Pauli-blocking allows
  for (TS)=(1/2 0)$(0s)^6$ configuration

only $\sqrt{\frac{9}{10}}\,|\Lambda N> + \sqrt{\frac{1}{10}}\,|\Sigma N>$ but not ~~$-\sqrt{\frac{1}{10}}\,|\Lambda N> + \sqrt{\frac{9}{10}}\,|\Sigma N>$~~

There is always Σ in Λ-hypernuclei. and Λ in Σ-hypernuclei.
This effect is essentially *nonlocal*.

Summary

- ✓ Construct a QCM potential (energy-*in*dependent nonlocal potential)
- ✓ Construct an on-shell equiv *local* potential
- ✓ To investigate the effect of nonlocality, compare the two potentials by looking into their G-matrices.
- ✓ $^{4}_{\Sigma}He$.
  - ◊ Use of the nonlocal potential is essential in strong Pauli-blocking channels. G-matrices of the two potentials are very different from each other in the channels where the quark Pauli-blocking effect is large. →Keep the nonlocality in the Kinetic term
  - ◊ Local approximation is good in weak Pauli-blocking channels. The QCM potential can be simulated by the local potential where the quark Pauli-blocking effect is small.