Exploring alternative SRG generators in one dimension

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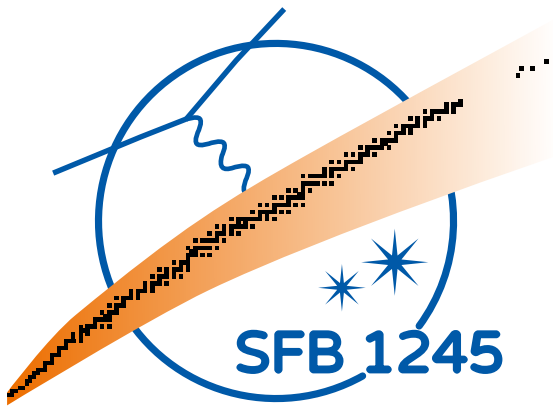
Matthias Heinz, Kai Hebeler, Achim Schwenk

DPG Spring Meeting 2019, Munich



Potentials in Nuclear Physics

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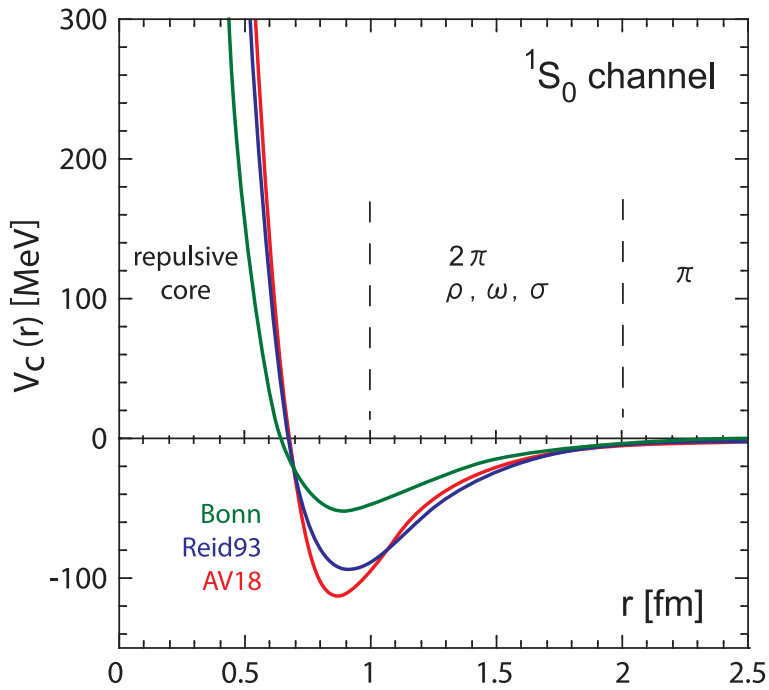
- Finite-range attractive force
- Short-range repulsion
- Repulsion couples low and high momenta
- Leads to poor many-body convergence



Aoki *et al.*, Comput. Sci. Dis. (2008)

The Similarity Renormalization Group (SRG)

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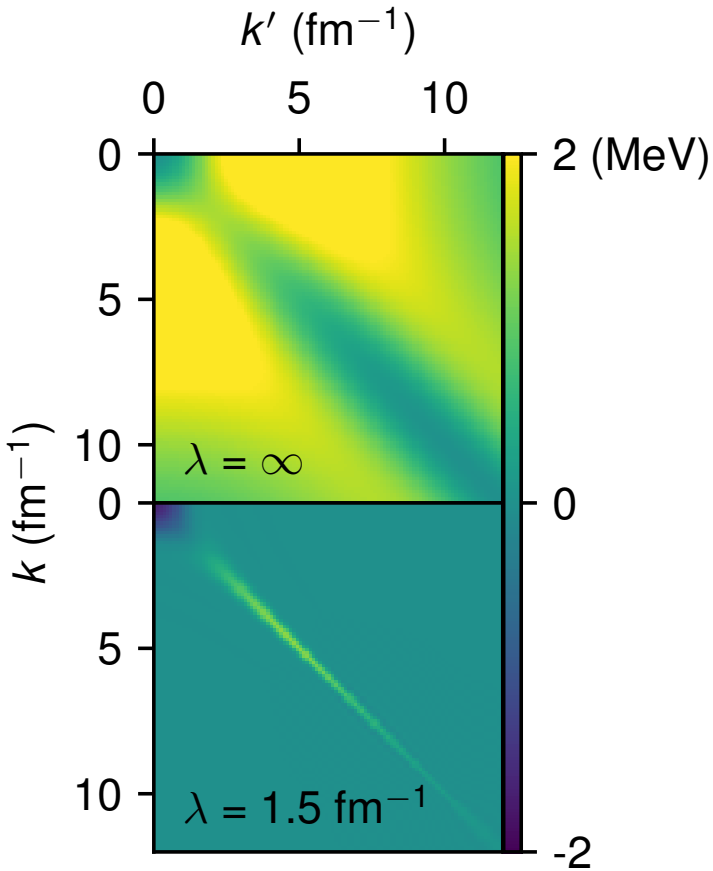
- Class of continuous unitary transformations given by:

$$\frac{dH_s}{ds} = [[G, H_s], H_s]$$

- $s = 1/\lambda^4$
- H_s goes to form of G
- Typical choice: $G = T_{rel}$ (right)



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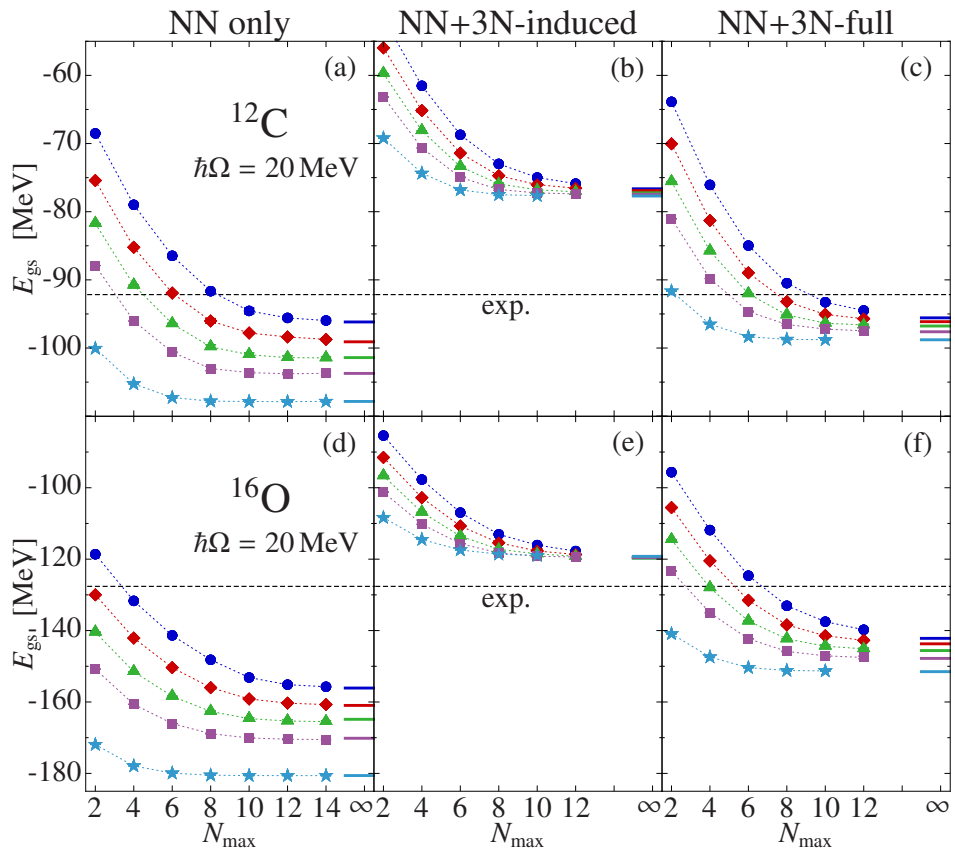
Features/Challenges:

- Improves many-body convergence
- Induces many-body forces



Roth *et al.*, Phys.Rev.Lett. 107 (2011) 072501

The Case for Alternative Generators

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For $G = T_{rel}$:

$$\frac{dV_s(k,k')}{ds} = -V_s(k,k')(k^2 - k'^2)^2 + ...$$

- Exponential suppression for far off diagonal matrix elements

The Case for Alternative Generators

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For $G = T_{rel}$:

$$\frac{dV_s(k,k')}{ds} = -V_s(k,k')(k^2 - k'^2)^2 + \ldots$$

- Exponential suppression for far off diagonal matrix elements

For $G_s = T_{rel} + X_s$ with $X_s(k,k') = W(k,k')V_s(k,k')$:

$$\frac{dV_s(k,k')}{ds} = -(V_s(k,k') - X_s(k,k'))(k^2 - k'^2)^2 + \ldots$$

- Change in matrix elements small when $X_s(k,k') = V_s(k,k')$
- Choose $W(k,k')$ to reflect what we want SRG to do

The Negele Model

Alexandrou *et al.*, Phys.Rev. C39 (1989)
Jurgenson, Furnstahl, Nucl.Phys. A818 (2009)

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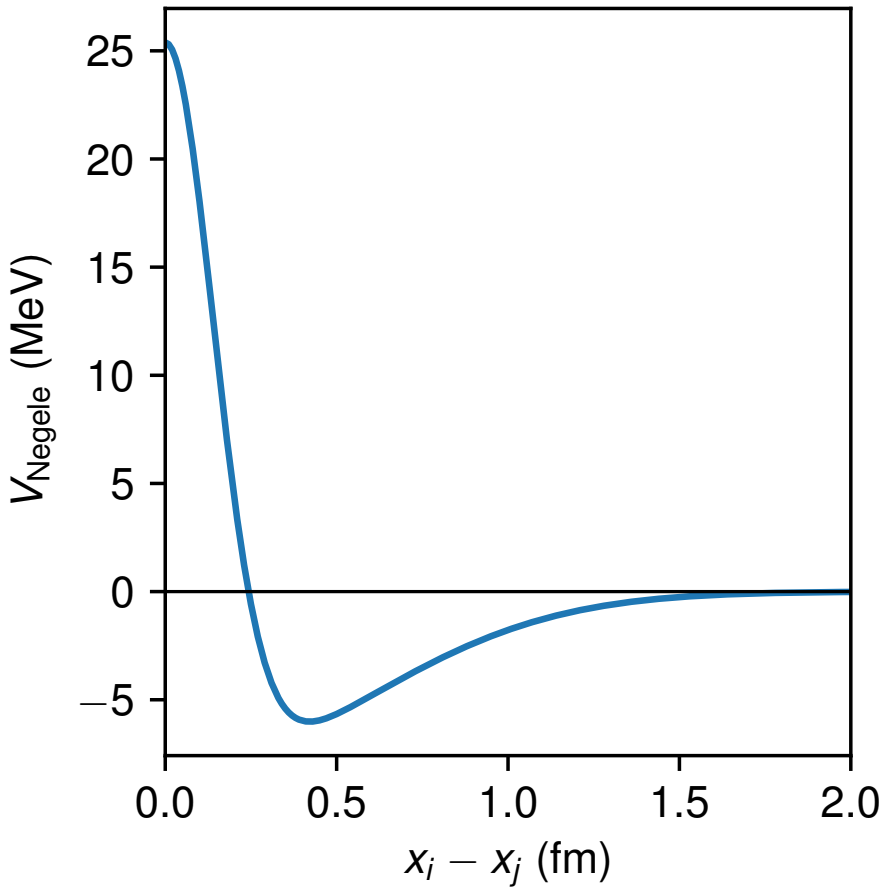
Features:

- 1-D
- Bosons
- Negele potential
- Jacobi harmonic oscillator for many-body results

Advantages:

- Model is simple
- Results generalize well to 3-D calculations



Generator: T_{rel}

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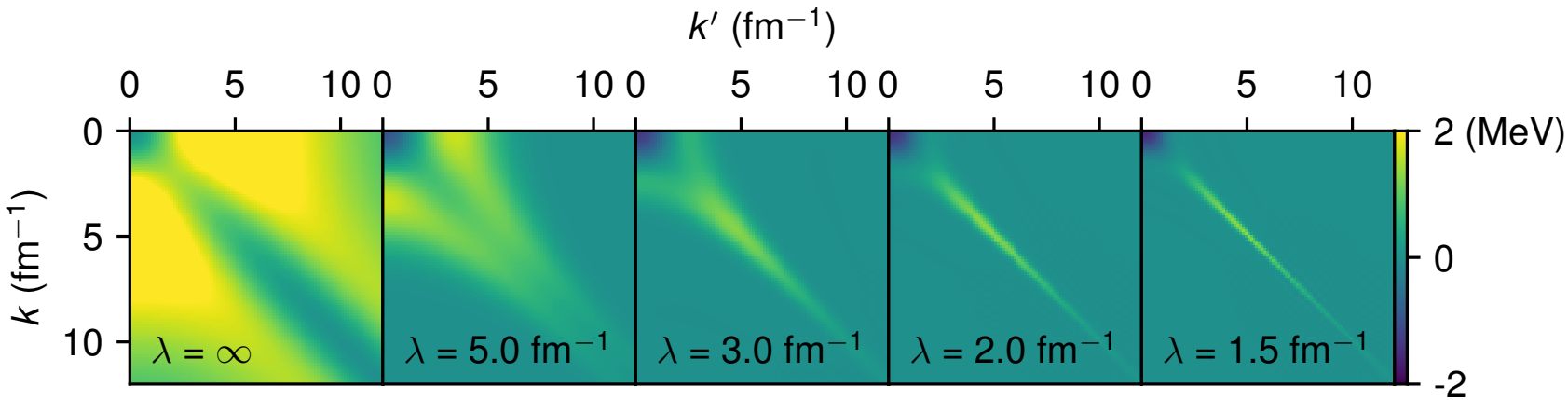
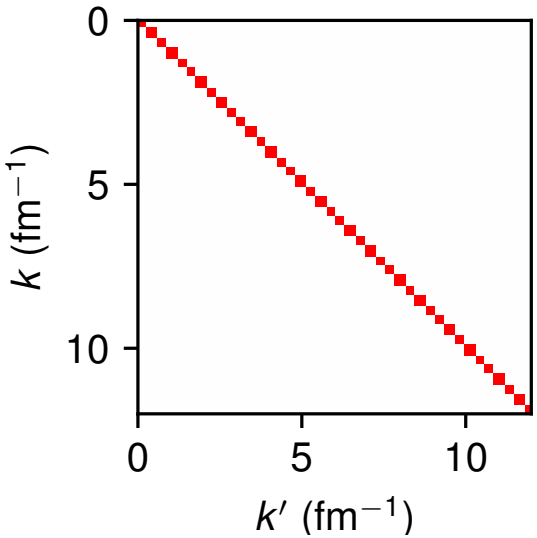
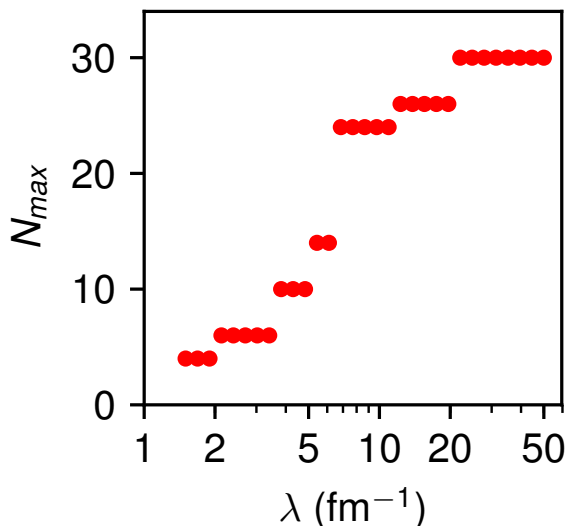


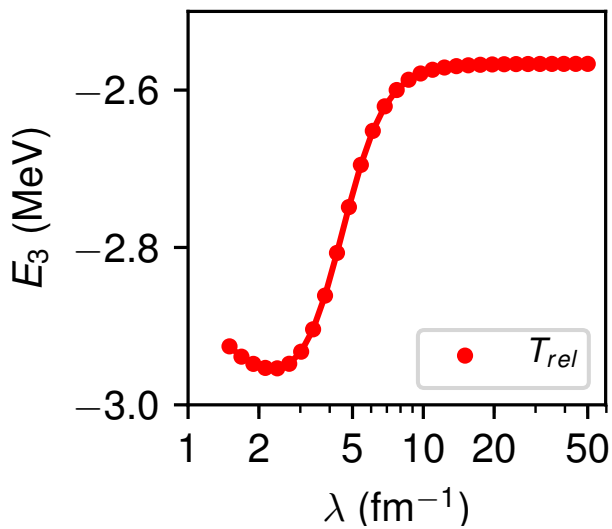
Generator Form



Decoupling



3-Body Binding Energy



Generator: Block Diagonal

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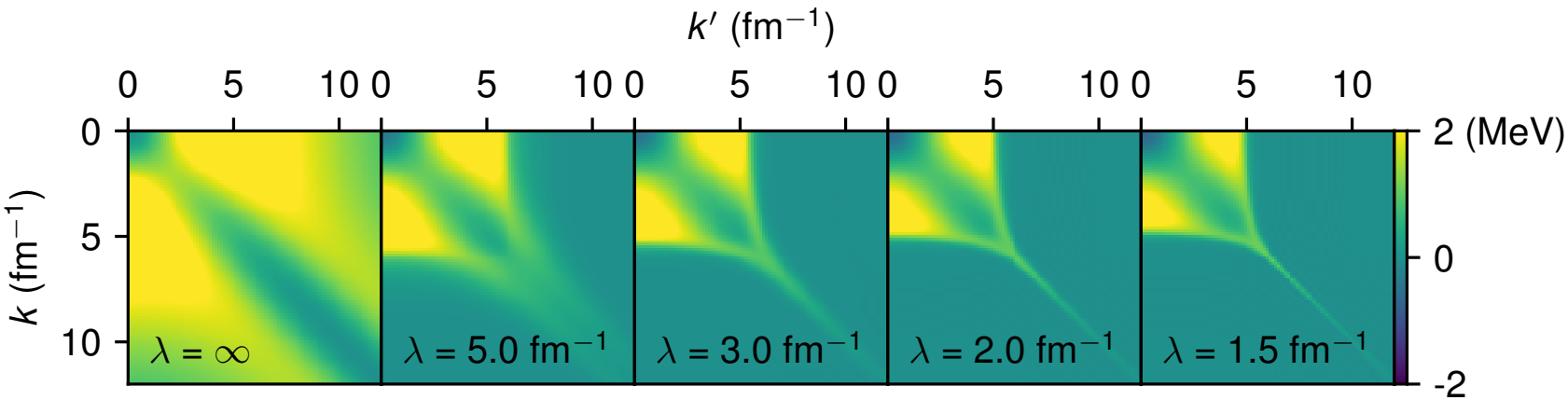
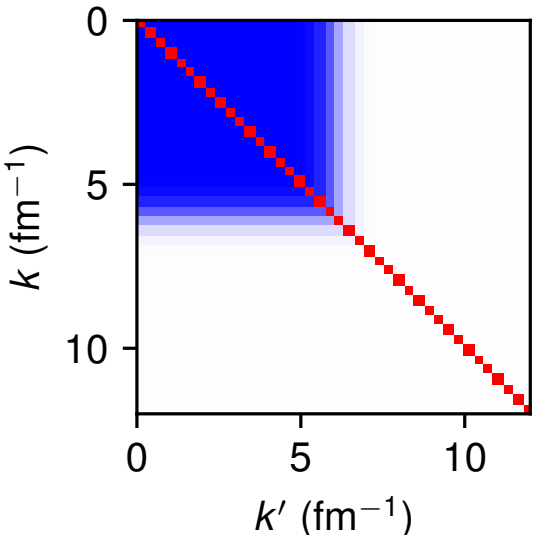


Generator Form



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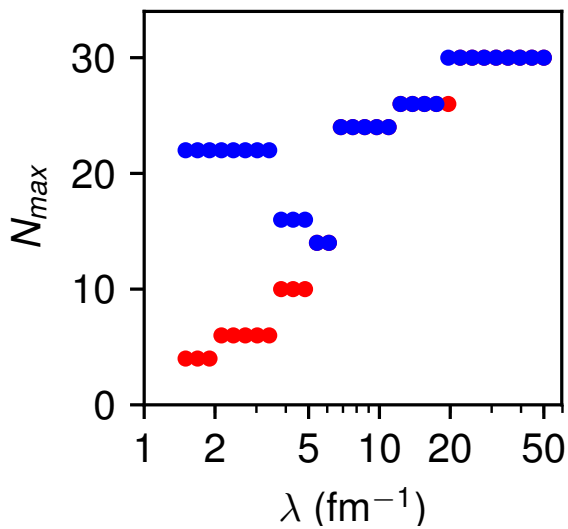

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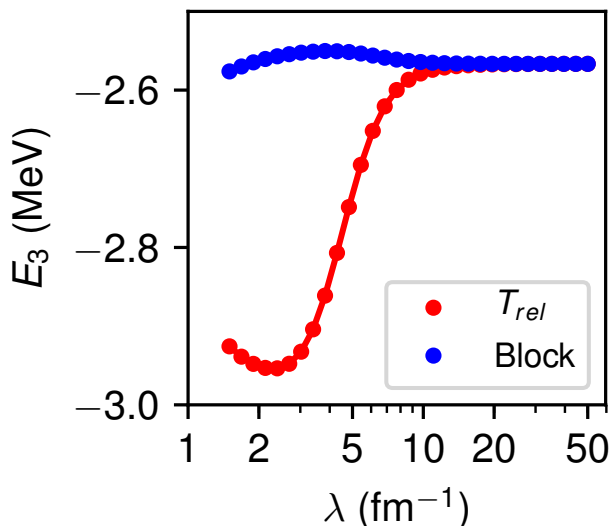

Generator: Band Diagonal

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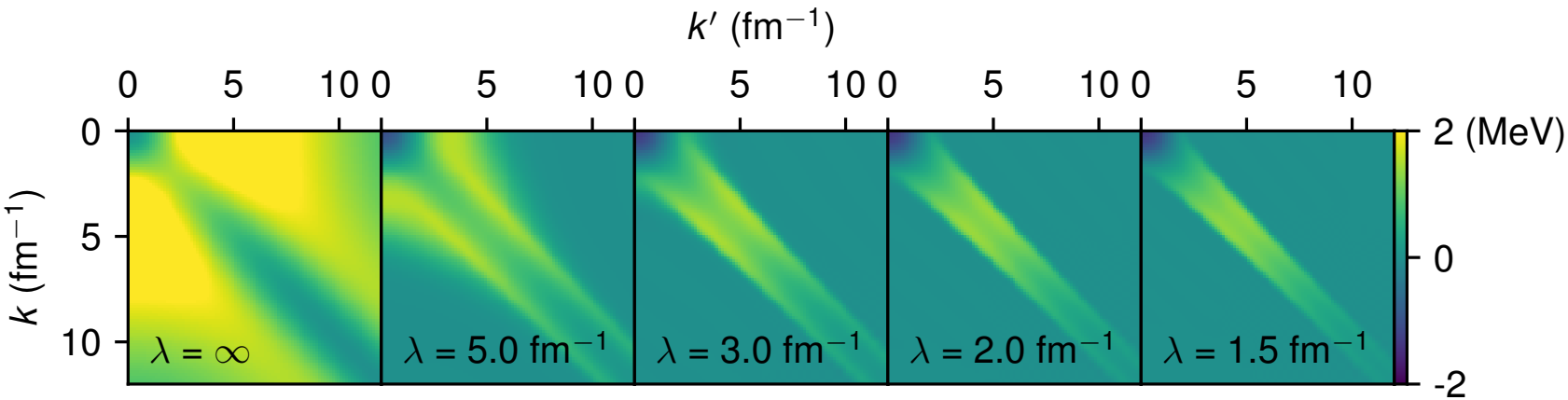

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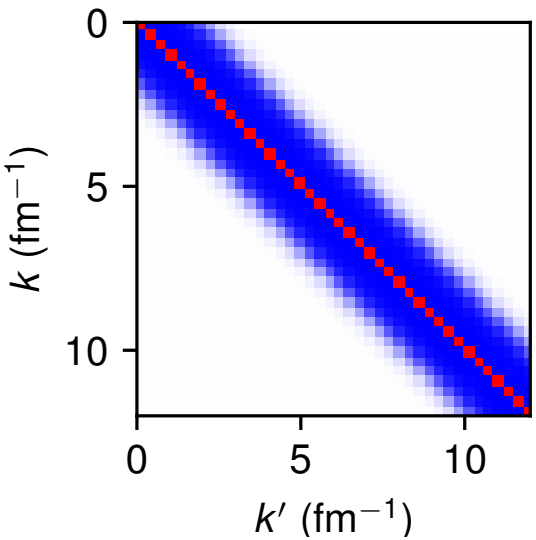

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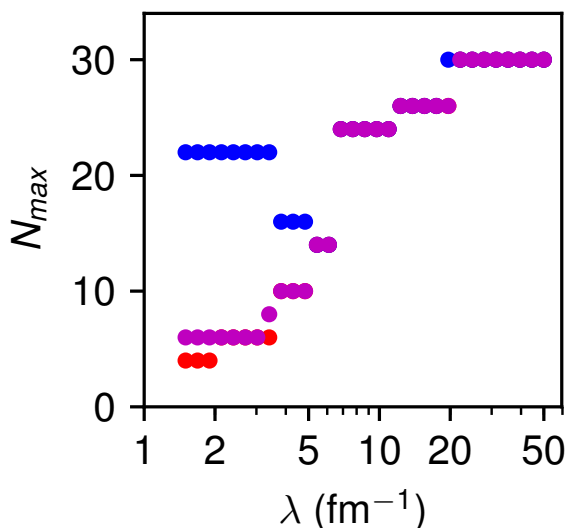

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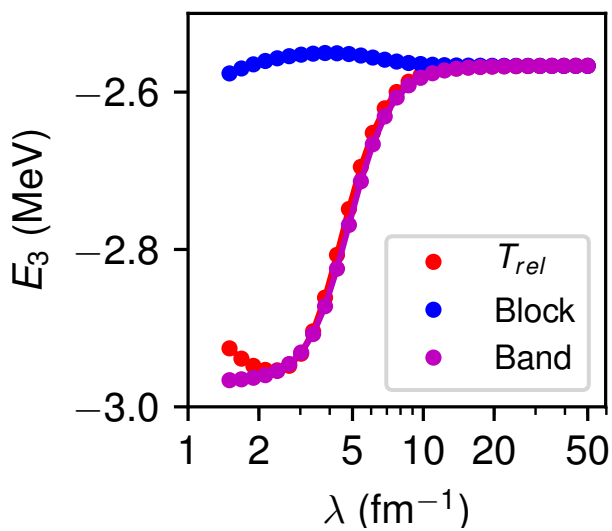

Outlook

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Status:

- Have framework to test alternative generators
- Considering generators of form $T + WV_s$
  provides an interesting way to explore alternative generators

Direction:

- Extend analysis to 4- and 5-body systems
- Learn what features of generators lead to what behavior
- Identify features that lead to small four and higher-body forces

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Thank you!