Possible Approach to Understand Nuclear Shell Structure Impacting Pairing

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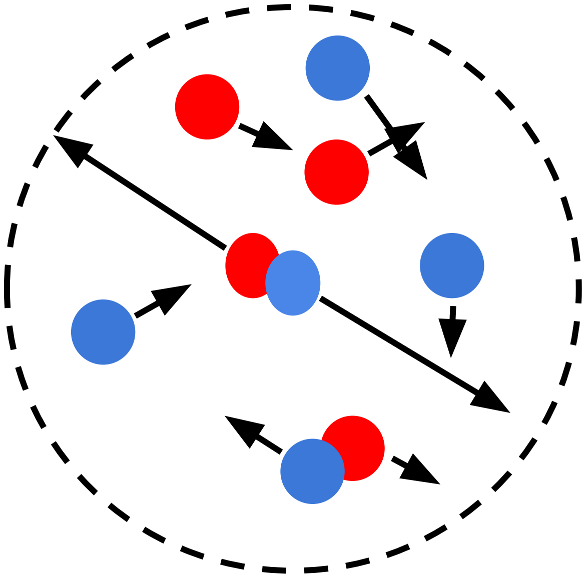

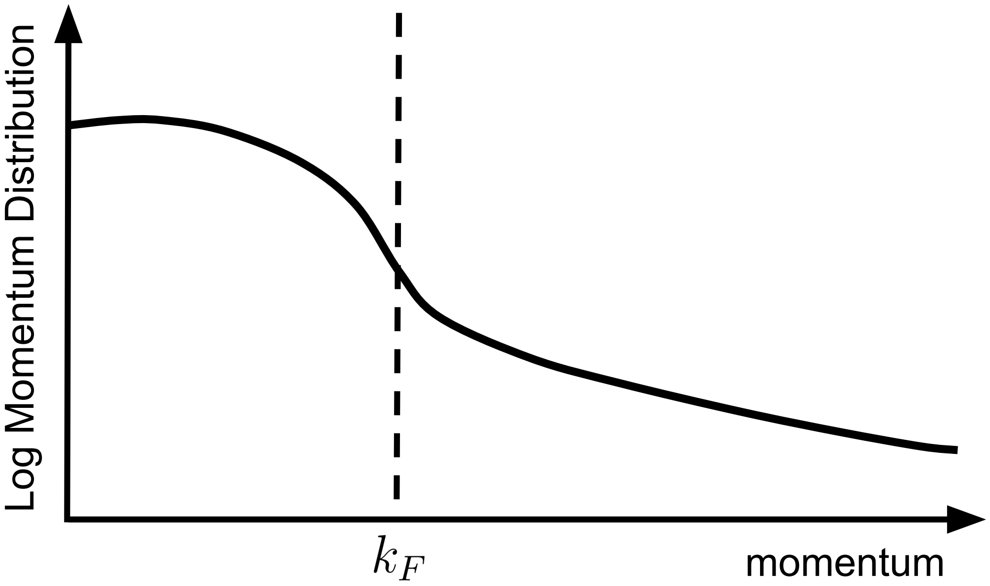

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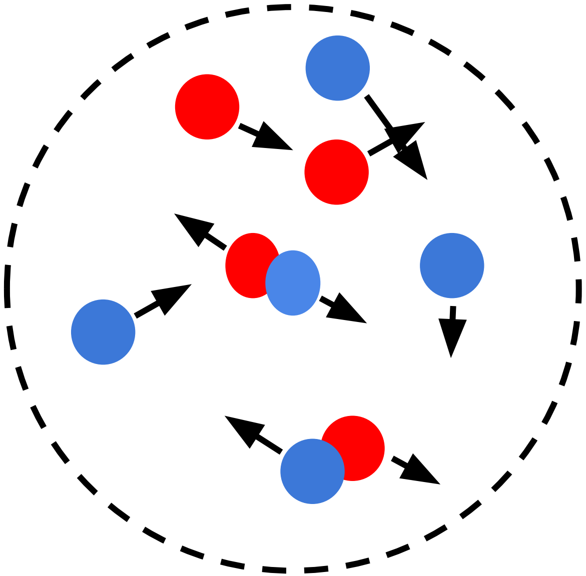
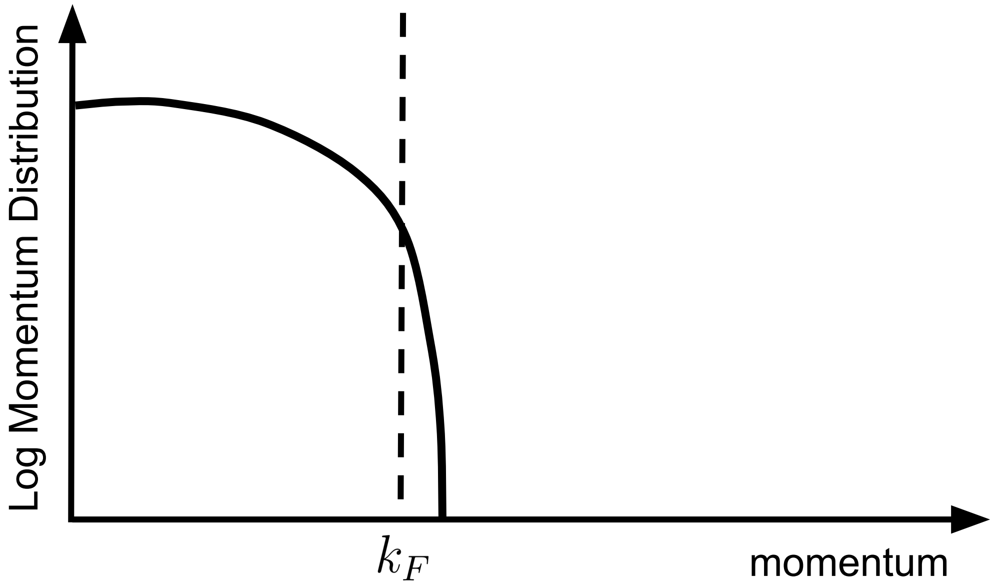




Wha

$$\langle \Psi_A^{LR} | H_{LR} | \Psi_A^{LR} \rangle = \langle \Psi_A^{HR} | H_{HR} | \Psi_A^{HR} \rangle$$

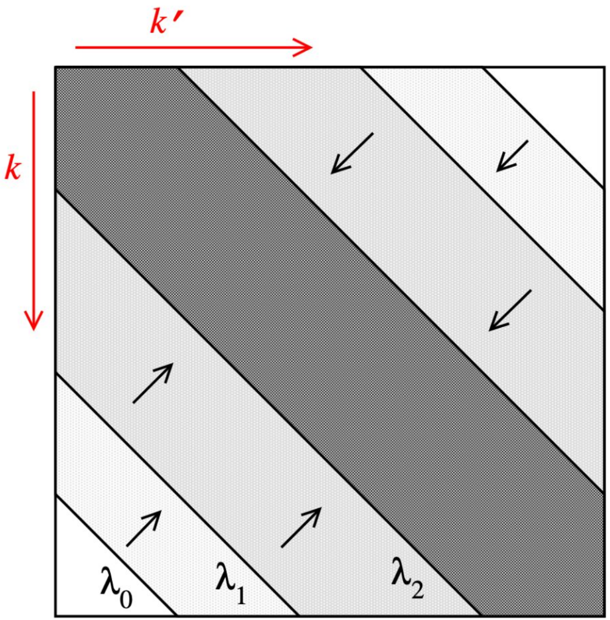
$$H_{LR} = U\, H_{HR}\, U^{\dagger}$$

k_F

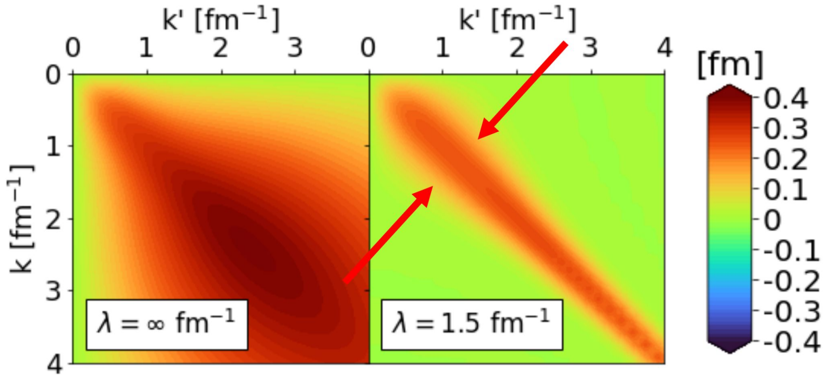
momentum

How to Connect Low and High Resolution Pictures?

Renormalization Group Methods



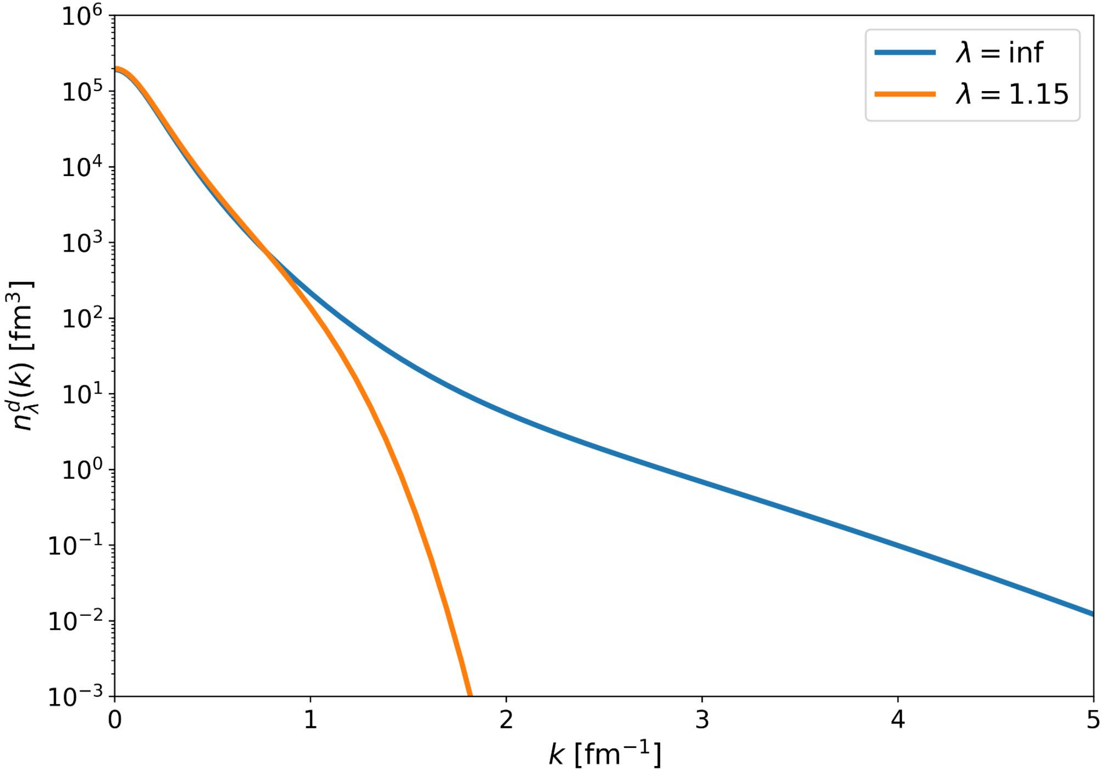
$$H(\lambda) = U(\lambda)\, H\, U^{\dagger}(\lambda)$$



Momentum-space matrix elements of Argonne v18 (AV18) under SRG evolution in $^1P_1$ channel. Figure adapted from AJT et al., Phys. Rev. C **102**, 034005 (2020).

Bogner, Furnstahl, Schwenk, Prog. Part. Nucl. Phys. 65 (2010)

Deuteron Example



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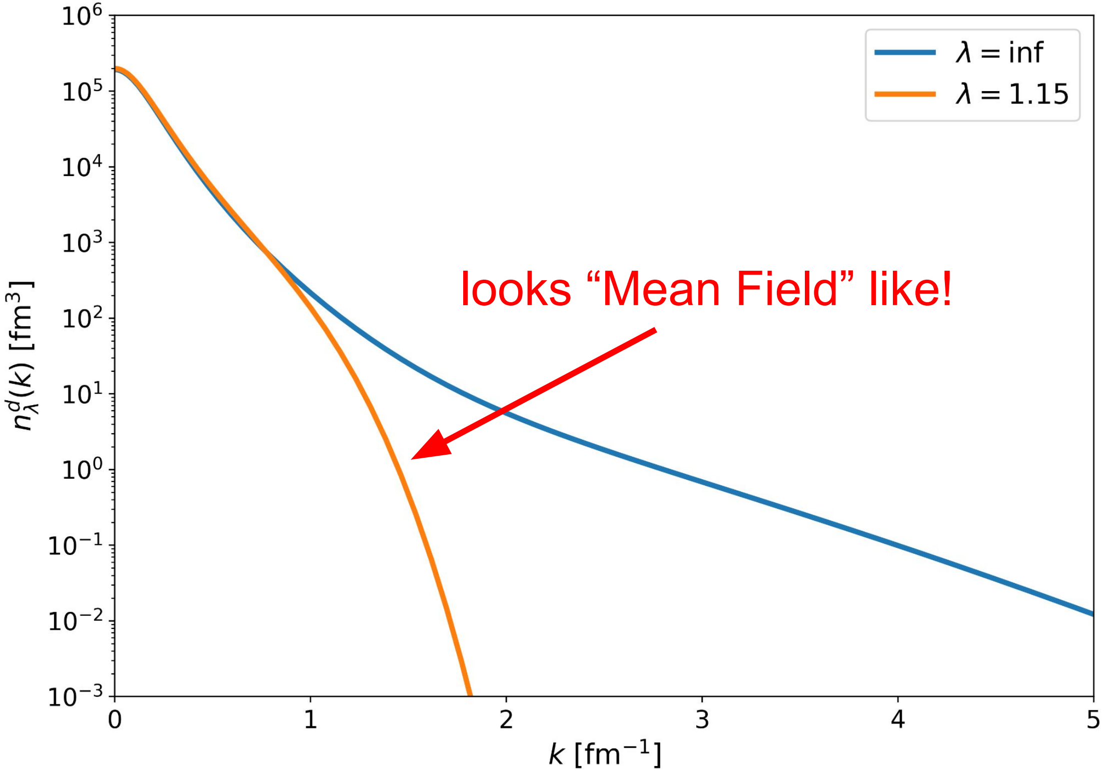

How to Study SRC Physics using Mean Field Theory

$$\langle \Psi_A | \hat{\mathcal{O}} | \Psi_A \rangle = \langle \underbrace{\Psi_A | U_\lambda^\dagger} \underbrace{U_\lambda \hat{\mathcal{O}} U_\lambda^\dagger} \underbrace{U_\lambda | \Psi_A} \rangle$$

$$= \langle \Psi_A(\lambda) | \hat{\mathcal{O}}(\lambda) | \Psi_A(\lambda) \rangle$$

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$$= \langle \Psi_A(\lambda) | \hat{\mathcal{O}}(\lambda) | \Psi_A(\lambda) \rangle$$

$$\approx \langle \Psi_A^{MF} | \hat{\mathcal{O}}(\lambda_{MF}) | \Psi_A^{MF} \rangle$$

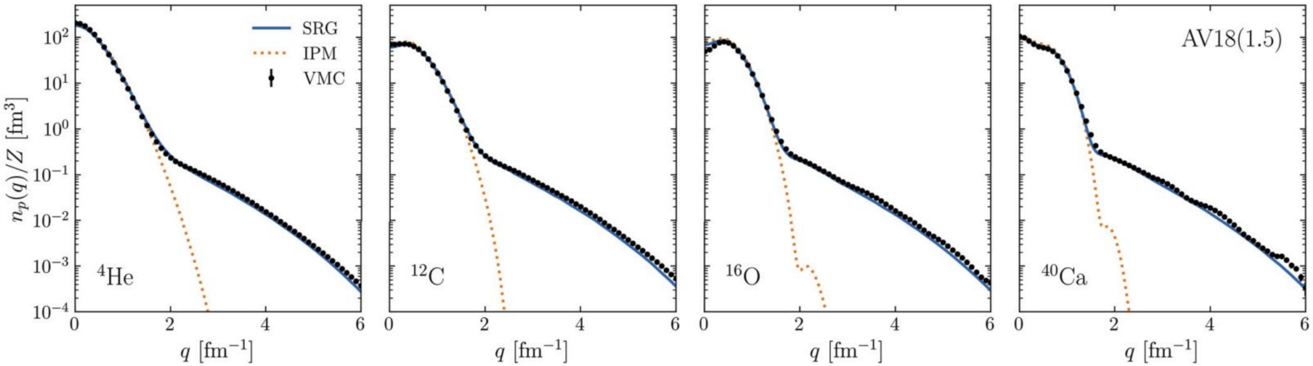

Fig. 2. Proton momentum distributions for ^{4}He, ^{12}C, ^{16}O, and ^{40}Ca. The solid blue lines show the SRG distributions in which the operator is evolved under the AV18 interaction at $\lambda = 1.5\,\text{fm}^{-1}$. The dashed orange lines show the IPM distributions (no operator evolution). The black points show VMC distributions calculated with AV18 and UX for ^{4}He and ^{12}C, and CVMC distributions calculated with AV18 and UIX for ^{16}O and ^{40}Ca. Each distribution is divided by the proton number Z.

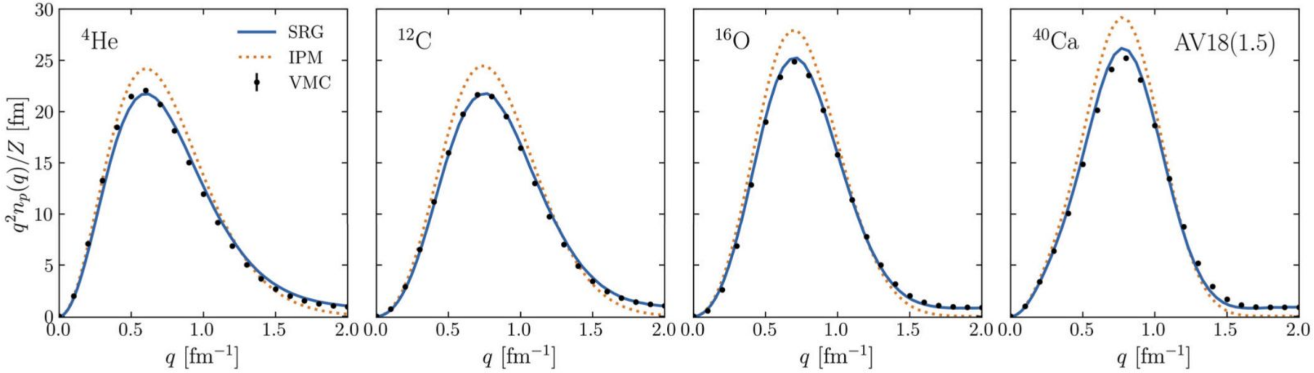

Fig. 3. Same as Fig. 2 but on a linear y-scale with a factor of q^2 included.

A.J. Tropiano et al. Phys. Lett. B 852 (2024) 138591

Takeaways

- Both High and Low Resolution pictures of the Nucleus are correct. The interpretation of SRC physics depend on your RG scale.
- Using a low resolution picture, the two body currents (from the NN interaction) that are generated by SRG seem to favor promoting np pairs in the same shell.
- SRG is formulated to understand scale dependence of Hamiltonians, nothing stopping one to use it in a Light-Front context (what I am working on!).