Variational wavefunctions for topologically-ordered Fermi liquids

Henry Shackleton

February 23, 2024

Harvard University

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w/ Shiwei Zhang, Flatiron Institute

Describing topological order with variational wavefunctions

Quantum spin liquids

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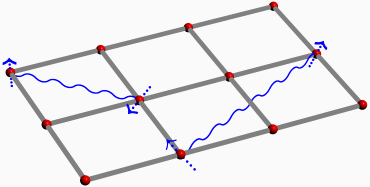

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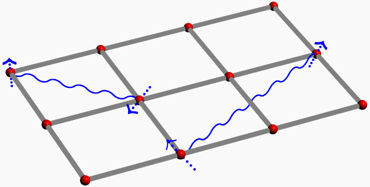

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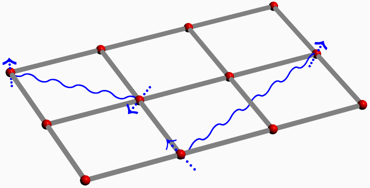

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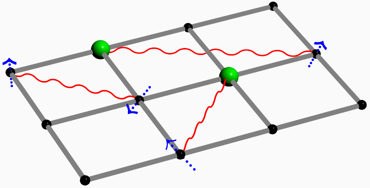

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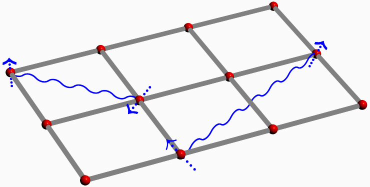

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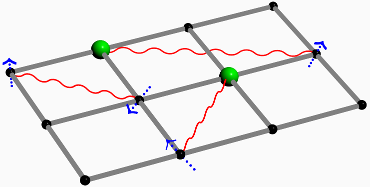

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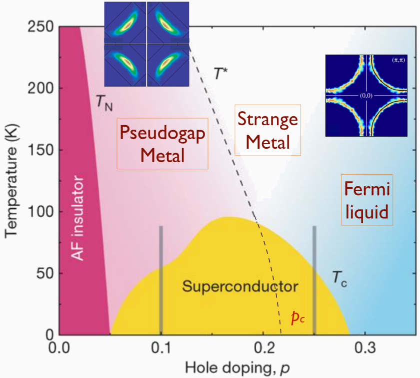
Variational WFs: this talk

Where are these variational wavefunctions useful?

Doped Mott insulators - capturing low temperature physics with TO[1]



[1]Lee, Nagaosa, and Wen, *Reviews of Modern Physics*, 2006
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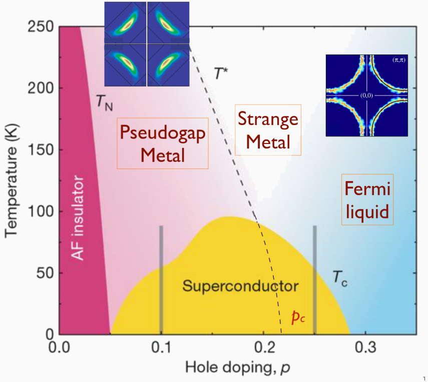
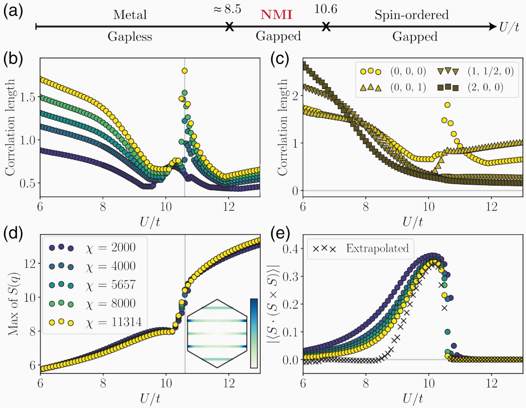


Chiral spin liquid in triangular lattice Hubbard model[2]



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Ancilla construction of topologically-ordered states[3]

Deviates from conventional $c_\alpha^\dagger \to f_\alpha b^\dagger$

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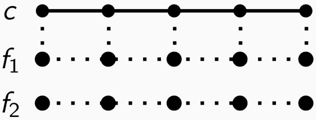

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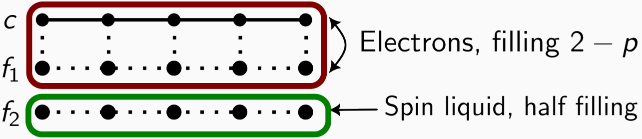

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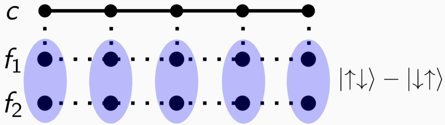

$$|\psi\rangle = \mathcal{P}_{SS}\left[|\psi_{c,f_1}\rangle \otimes |\psi_{f_2}\rangle\right]$$

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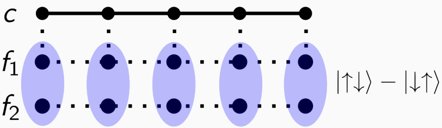

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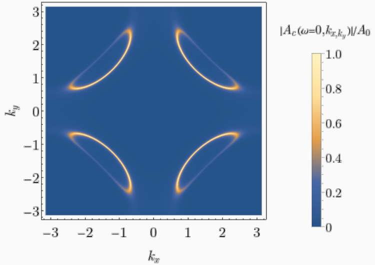

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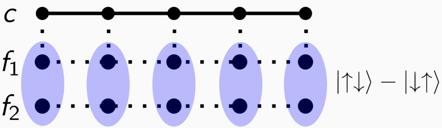

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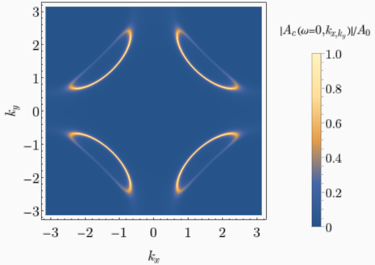

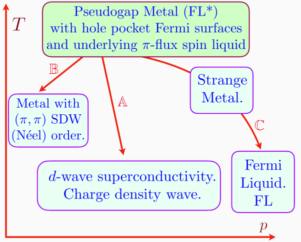

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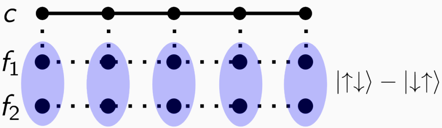

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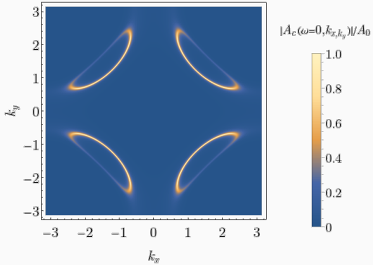
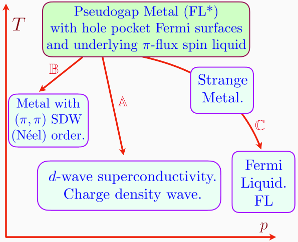
Full rung singlet projection exponentially hard, instead use $e^{-\beta \sum_i (S_{1i}+S_{2i})^2} \mathcal{P}_{S_z=0} |\psi_0\rangle$





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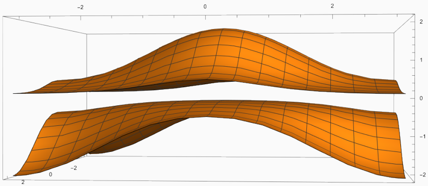
Half-filling: WFs behave favorably energetically ($\beta = \infty$)



Simple ansatz: $t_c = t$, $t_1 = 0$ gives mean-field charge gap 2Φ, which we fix to be U

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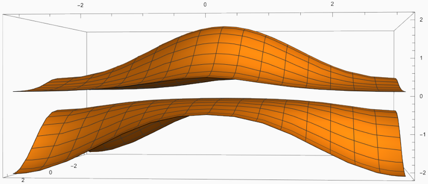

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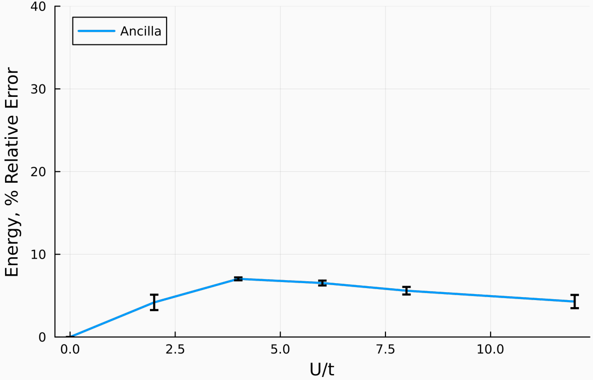

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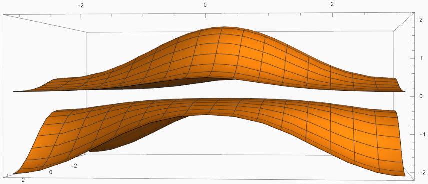

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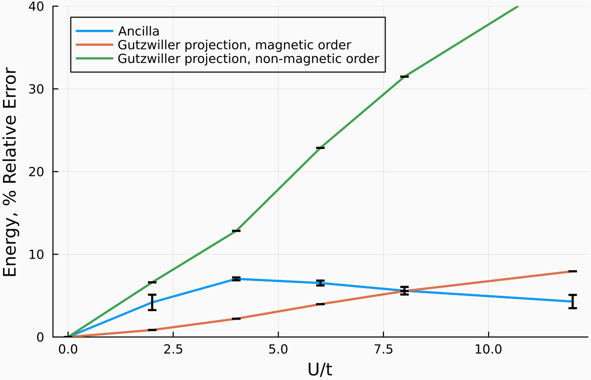
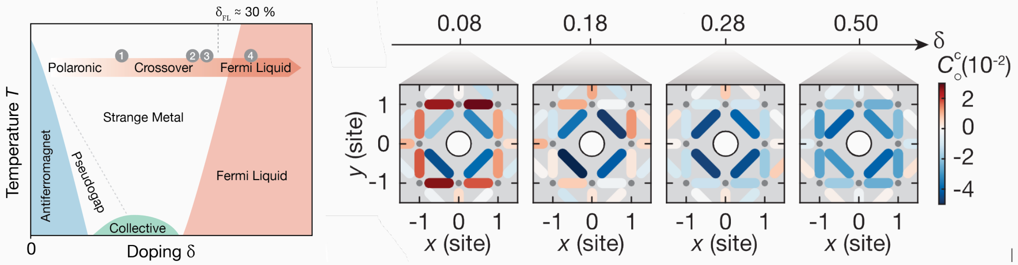


Polaronic correlations essential for capturing doped Mott insulators



Koepsell et al., Science, 2021

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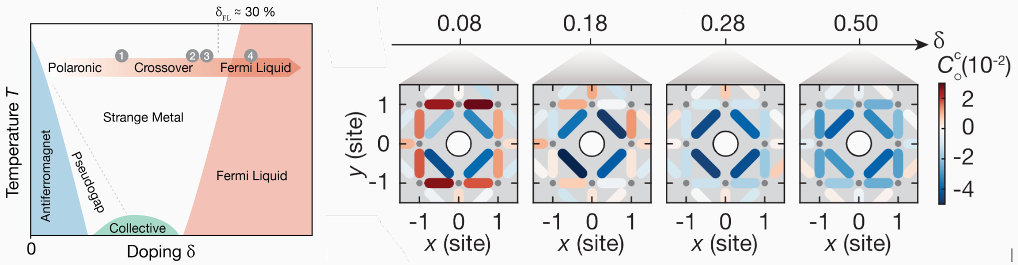
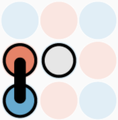


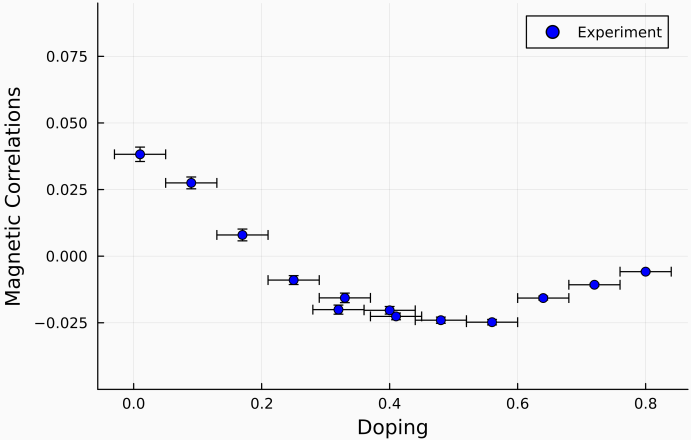
Do these wavefunctions support polaronic correlations?

Koepsell et al., Science, 2021

Nearest neighbor magnetic correlations ($U/t = 7.4$)

Polaronic correlations probed by multipoint correlator $\langle h_i S_j^z S_k^z \rangle$





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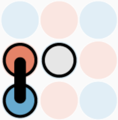

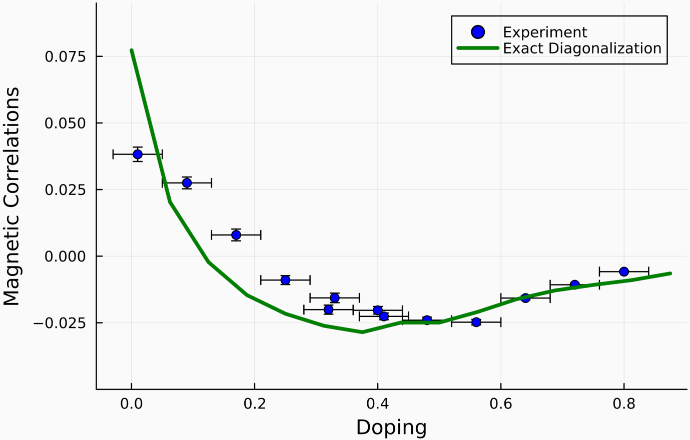

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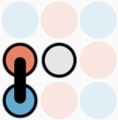

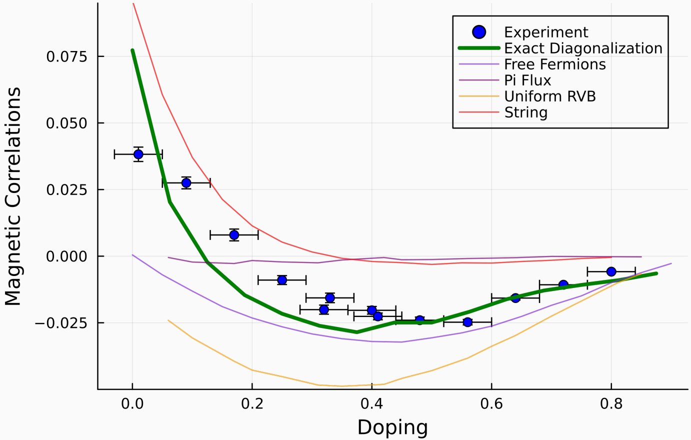

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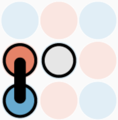

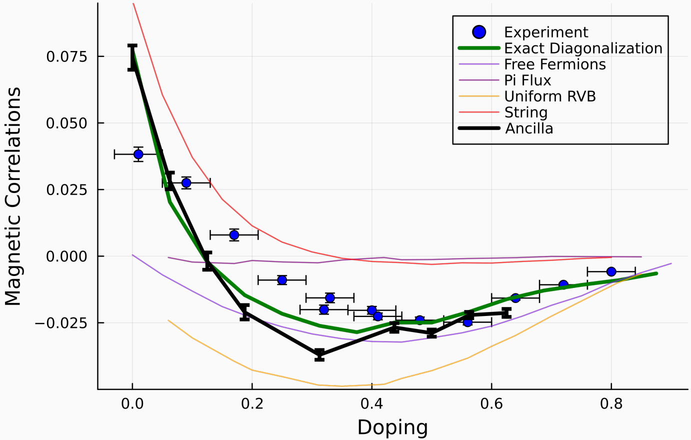

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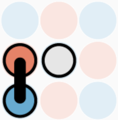

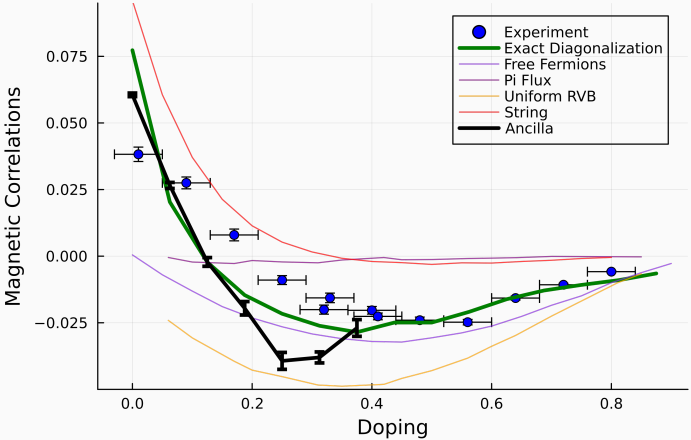

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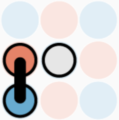

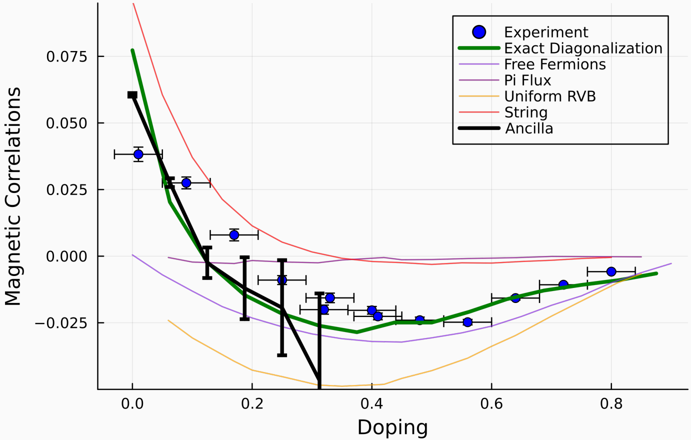

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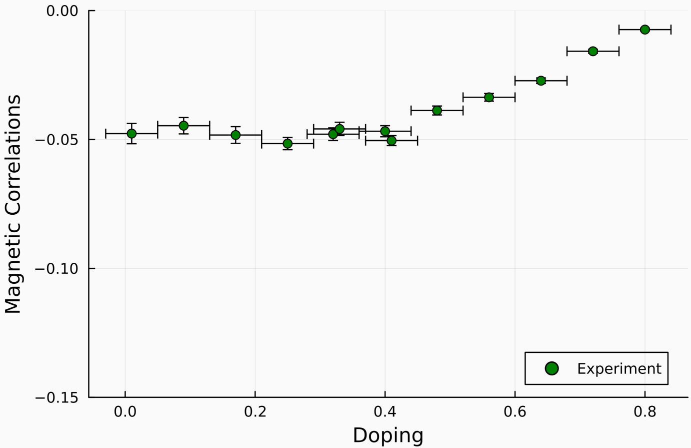

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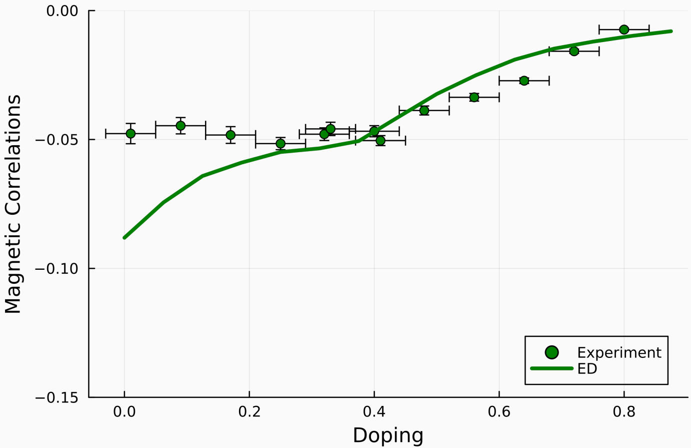

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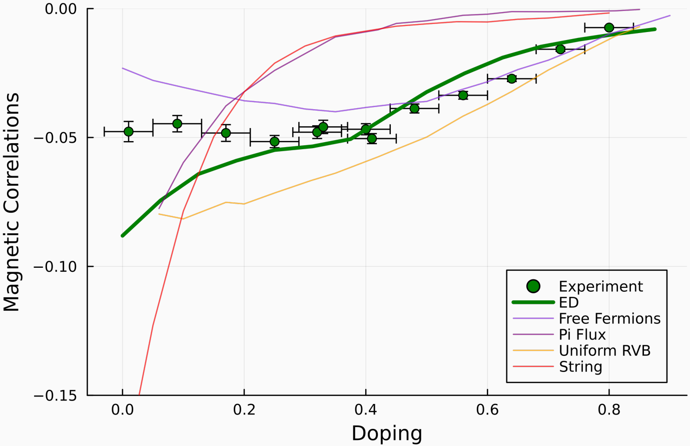

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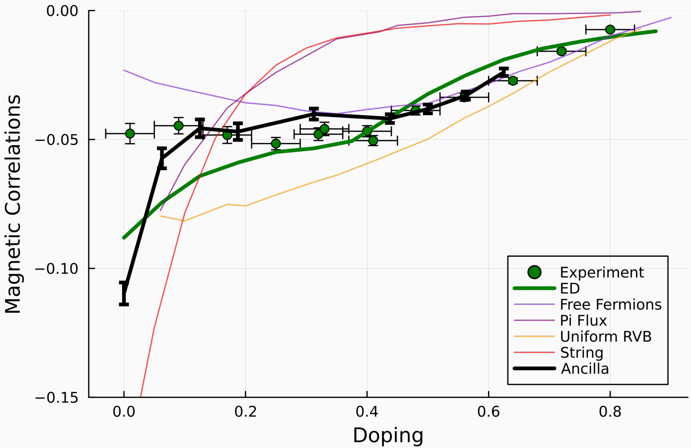

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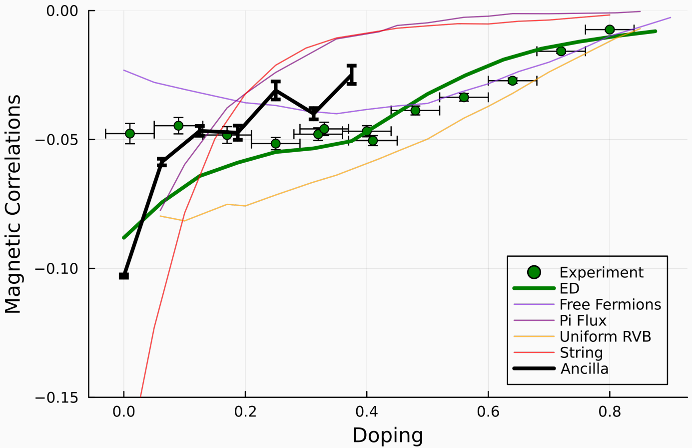

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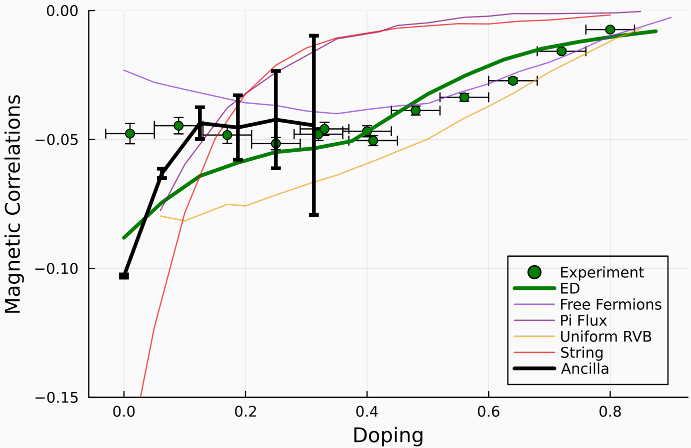

Conclusions and future directions

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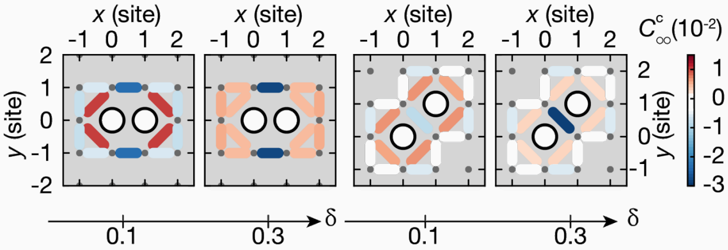

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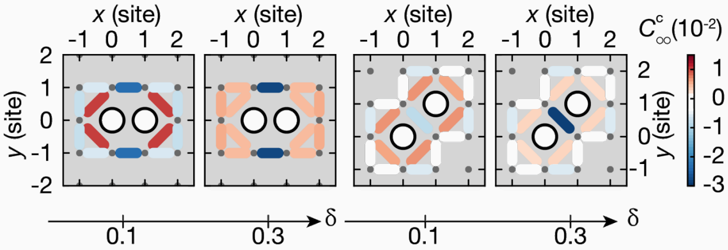

- CSL on triangular lattice Hubbard model - which CSL?[4]

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