UCLA College | Physical Sciences
Physics & Astronomy

Tensor Networks for Energy Correlators

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Work in Progress with Enrico Hermann, Zhongbo Kang, Kyle Lee, Noah Moran.

Goal: To compute **Energy-correlators** non-perturbatively using **Tensor Networks.**

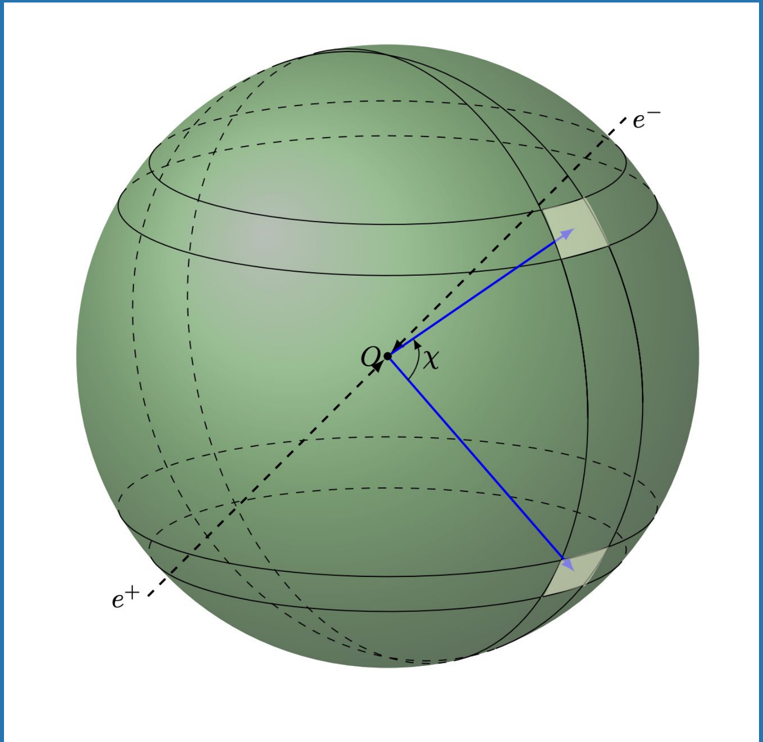
Energy Energy Correlators (EECs)

$$\mathcal{E}(\hat{n}) = \int dt \lim_{r\to\infty} r^{d-2}\, \hat{n}^i\, T_{0i}(t, r\hat{n})$$

Energy-flow operator
(calorimeter cells)

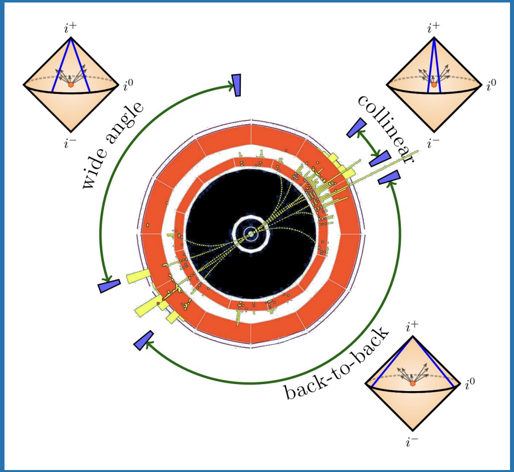
$$\mathrm{EEC}(\hat{n}_1, \hat{n}_2) = \langle \psi \,|\, \mathcal{E}(\hat{n}_1)\, \mathcal{E}(\hat{n}_2) \,|\, \psi \rangle$$

Energy Energy Correlator



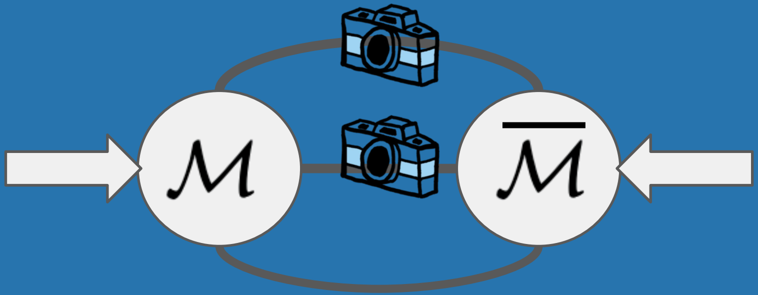
arxiv.2203.07113

Energy Energy Correlators (EECs)



- Why are EECs Interesting?
  - CFT
  - Experiment

- Well Studied, relation to Amplitudes



- Here:
  - We use operator perspective

Tensor Networks: (arxiv.1603.03039)

- Used in condensed matter and quantum information theory.

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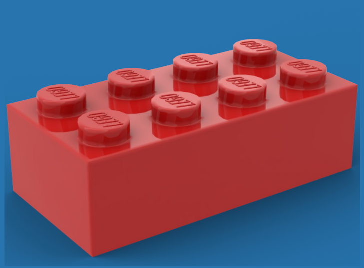

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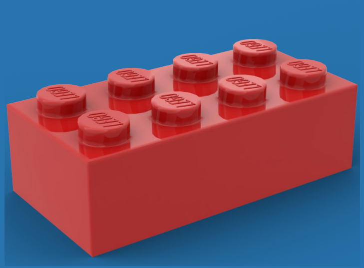

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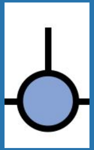

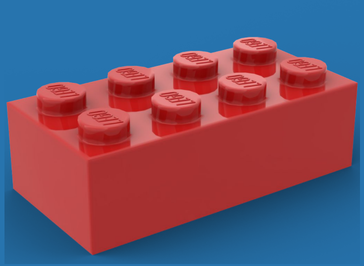

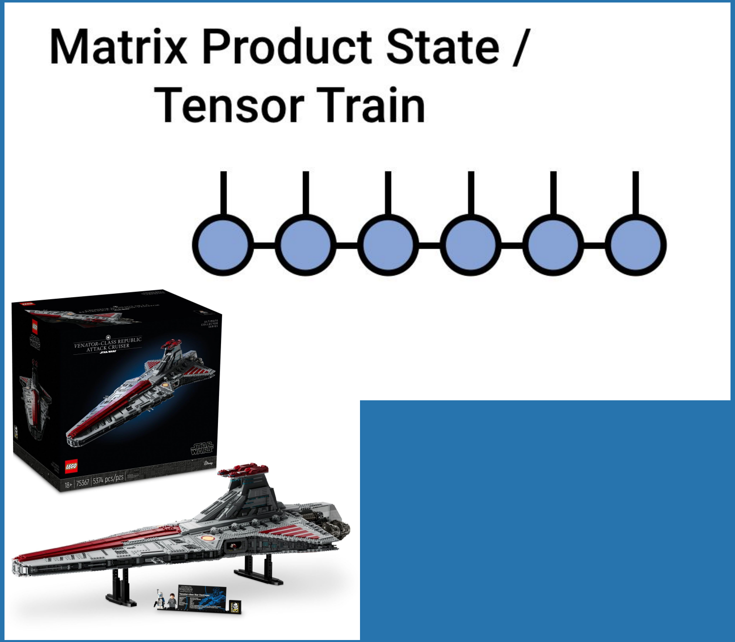

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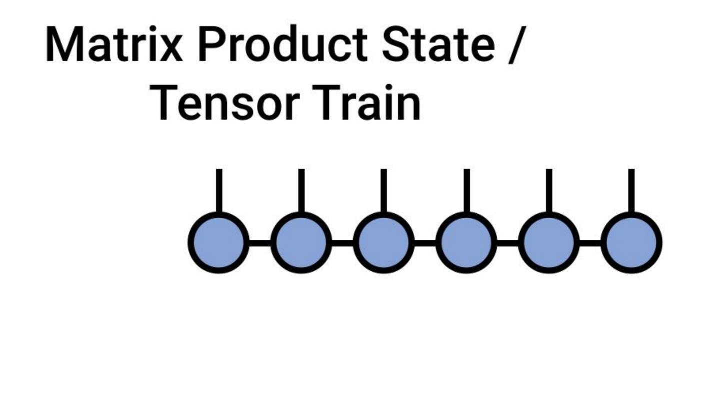
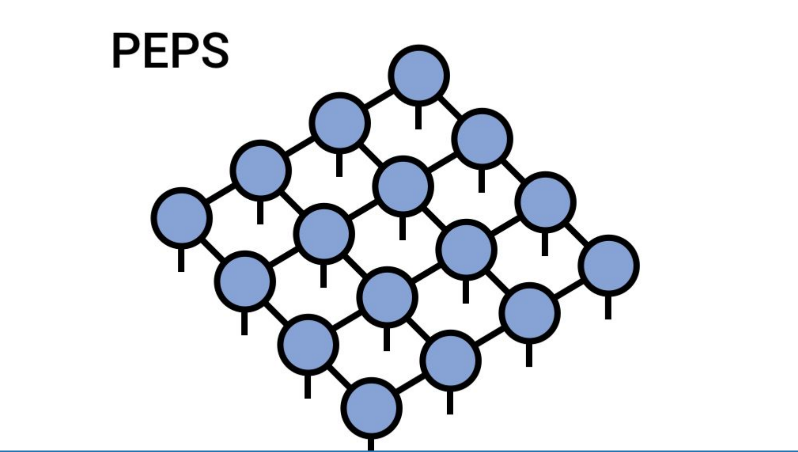


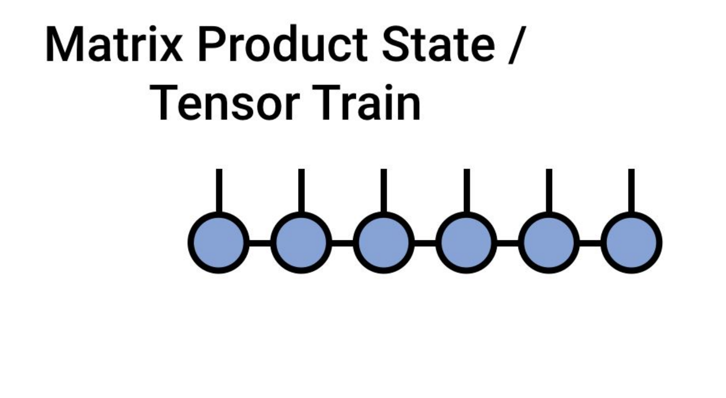
1+1D



2+1D

Tensor Networks: (arxiv.1603.03039)

- Used in condensed matter and quantum information theory.
- PEPS: Projected Entangled Pair States



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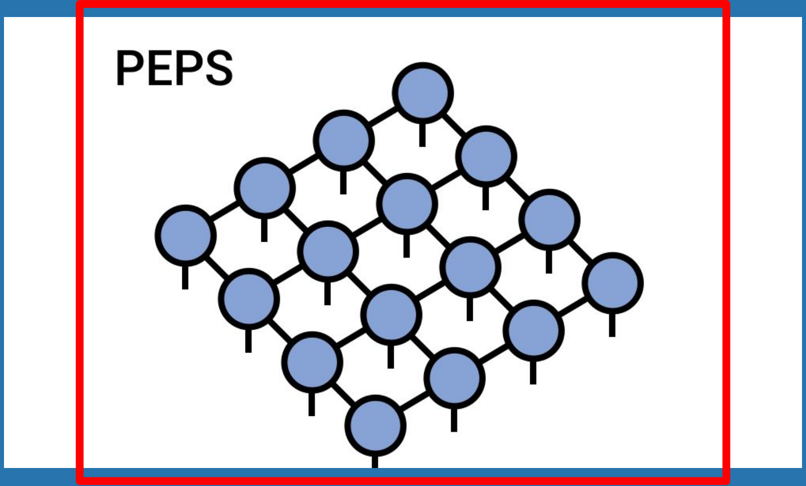
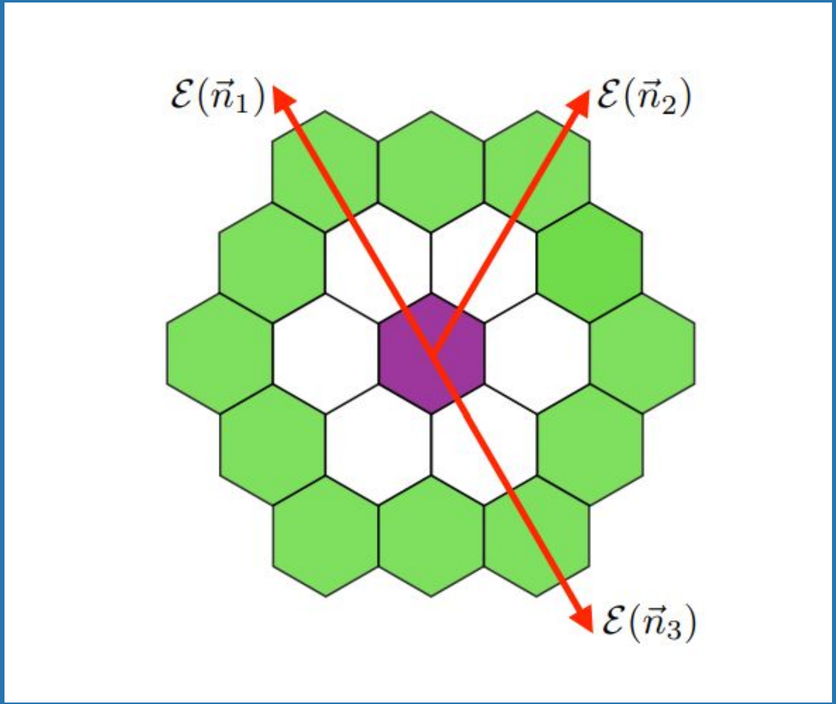


2+1D

Lee, Turro, Yao (arxiv.2409.13830) EEC setup

- SU(2) Lattice Gauge Theory in 2 + 1D, with truncations.
- Each site i = qubit, s.t.

$$O_S = \sum_{\{\mu_j \in \{0,x,y,z\}\}} c_{\{\mu_j\}} \bigotimes_{j \in S} \sigma_j^{\mu_j} \quad (\sigma^0 \equiv I).$$



Lee, Turro, Yao (arxiv.2409.13830) EEC setup

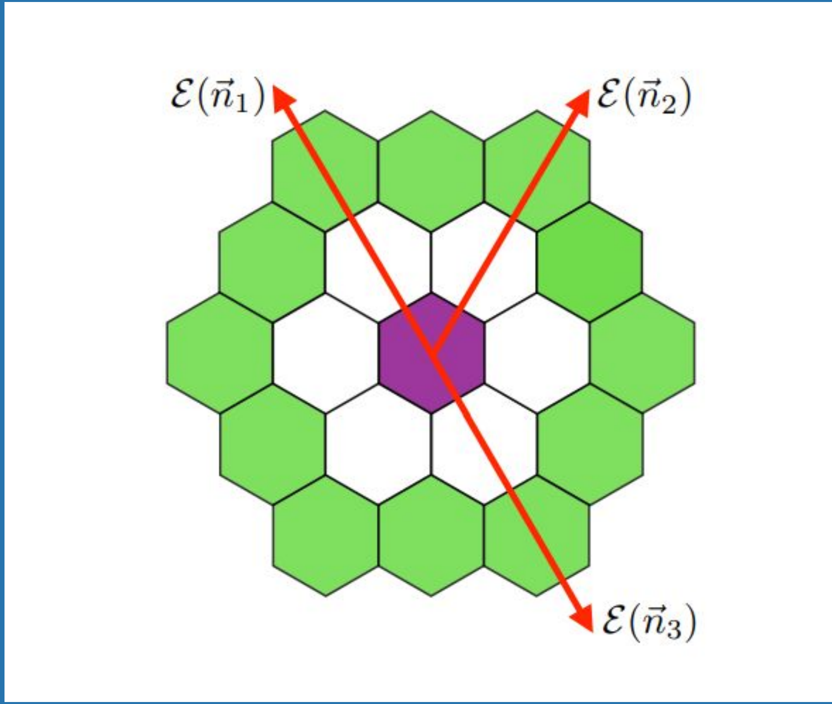
- E.g. Hamiltonian:

Basis $\rightarrow$ $\Pi_i^{\pm} = \dfrac{I_i \pm \sigma_i^z}{2}$ & $D_{ij} = \prod_{K=0}^{5} \left[\left(\frac{1}{2} - \frac{i}{2\sqrt{2}} \right) \sigma_K^z \sigma_{K+1}^z + \frac{1}{2} + \frac{i}{2\sqrt{2}} \right]$

$$\Downarrow$$

$$\begin{aligned} H_{ij} &= H_{ij}^{\mathrm{el}} + H_{ij}^{\mathrm{mag}} \\ &= h_+ \Pi_{ij}^+ - \frac{h_{++}}{2} \Pi_{ij}^+ \sum_{(i',j')} \Pi_{i'j'}^+ + h_x \sigma_{ij}^x D_{ij} \end{aligned}$$

The Setup



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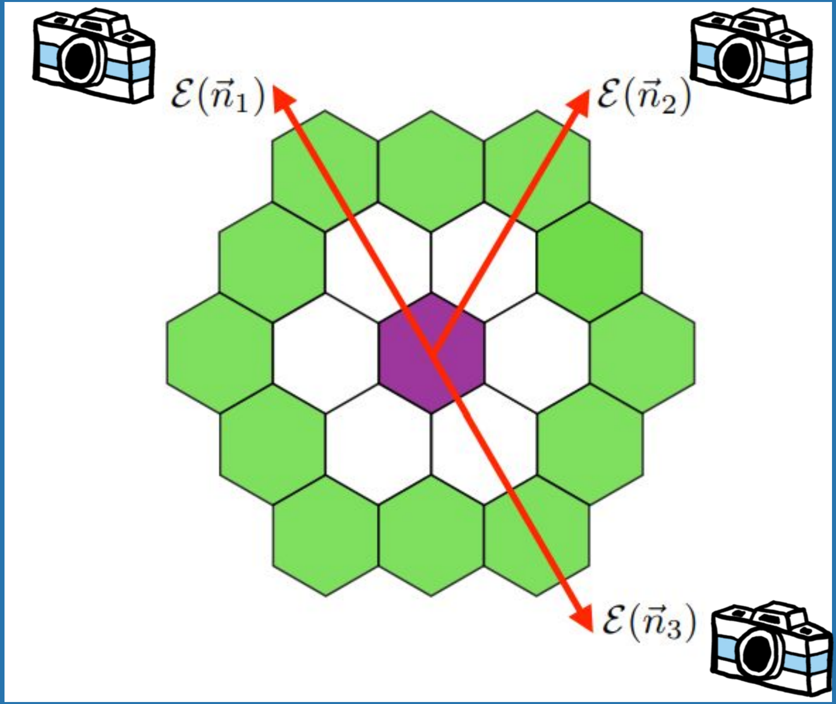

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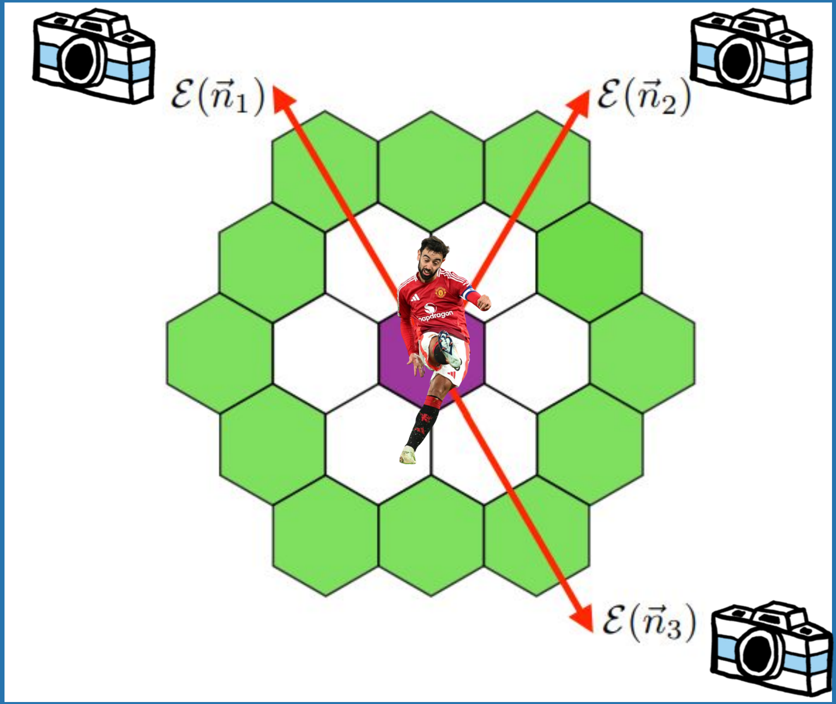

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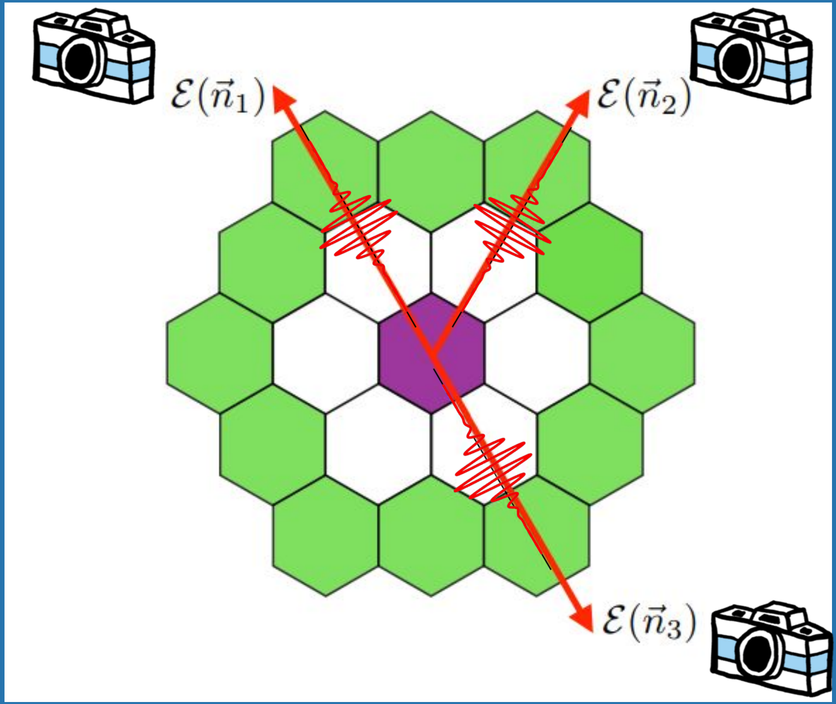

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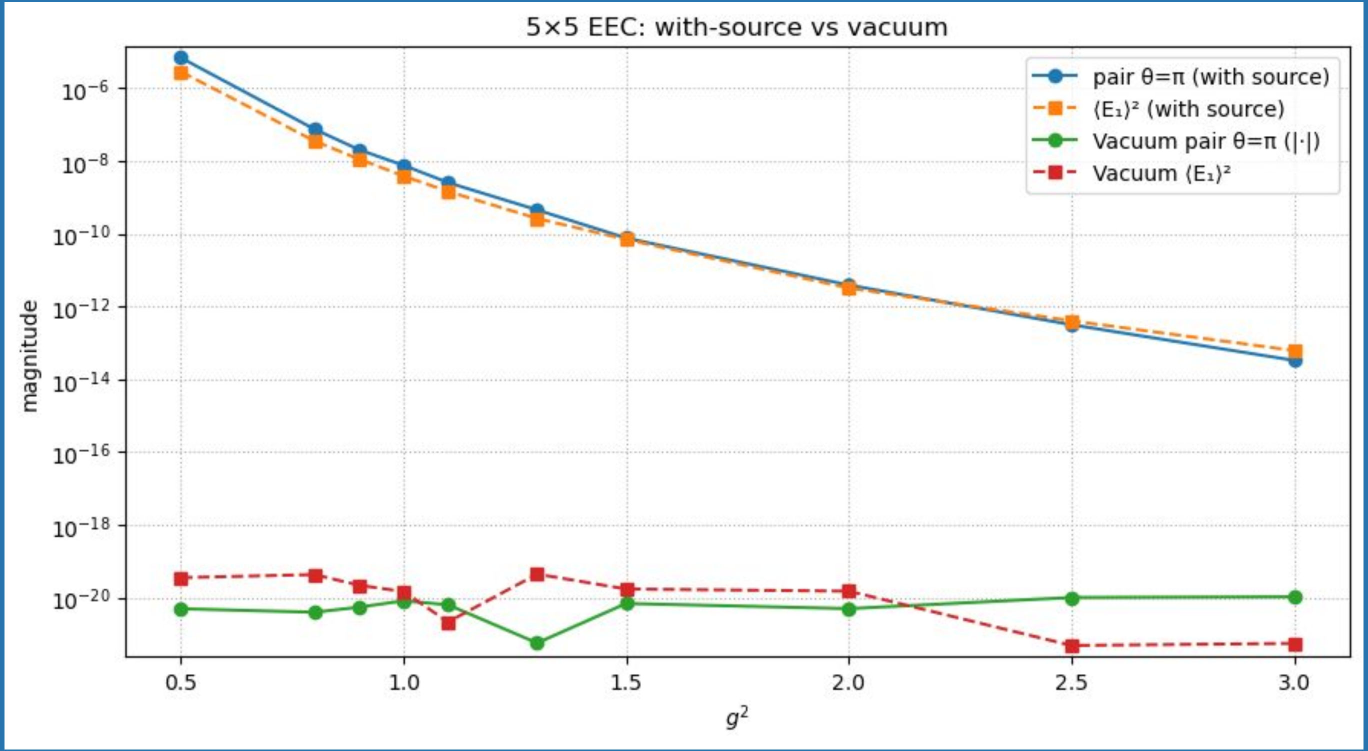
Verification



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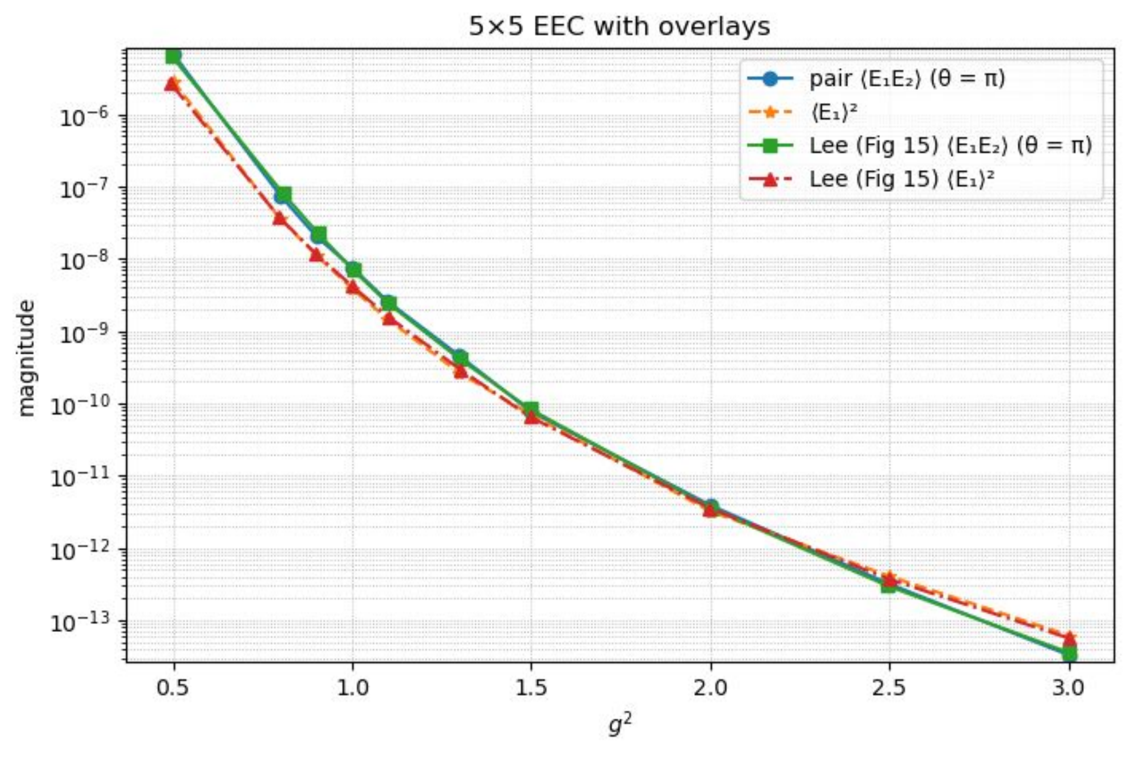
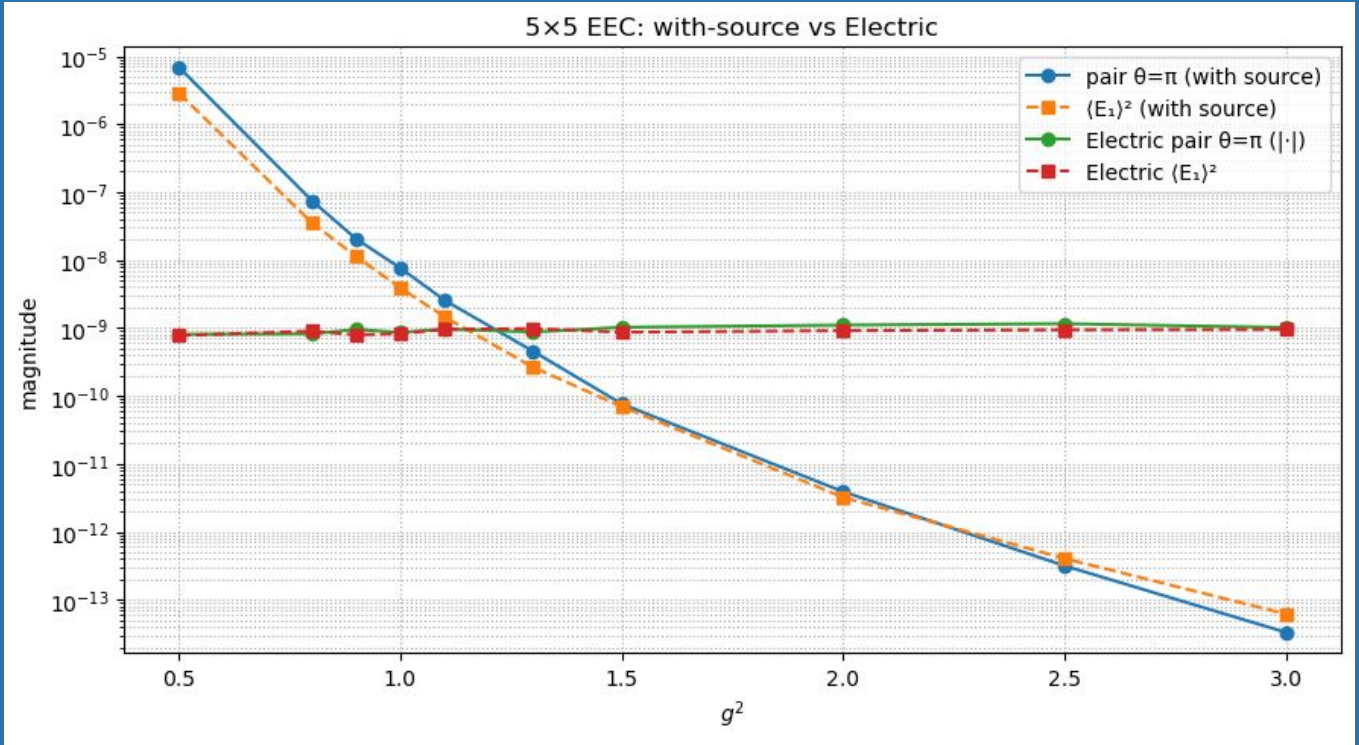


Initial Results

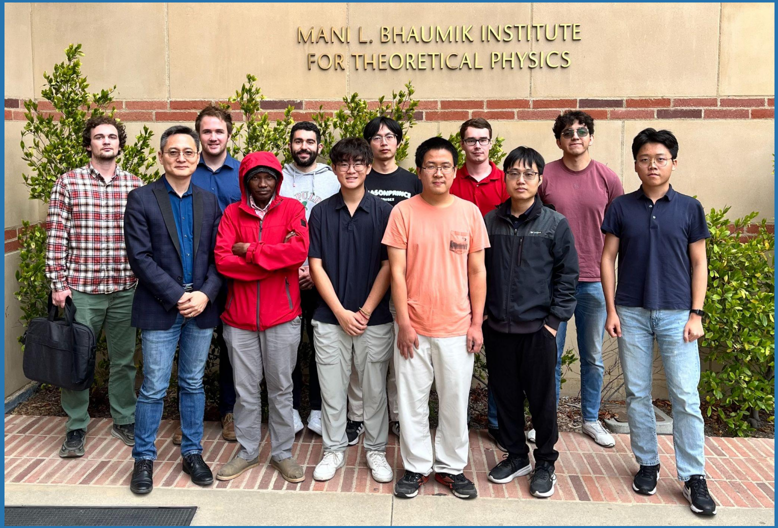


Future (currently ongoing) work

- GPU acceleration of software
  - Faster results and better performance
- Raising truncation (difficult in current setup)
- **Look for jets** in the SU(2) case

- 3D Ising CFT ↔ 2D TFIM
  - Study Ising CFT (2+1D) by simulating 2D TFIM at criticality with PEPS
  - No truncation!

Acknowledgements



Not Pictured - Enrico (in audience), Kyle.


Thank you!