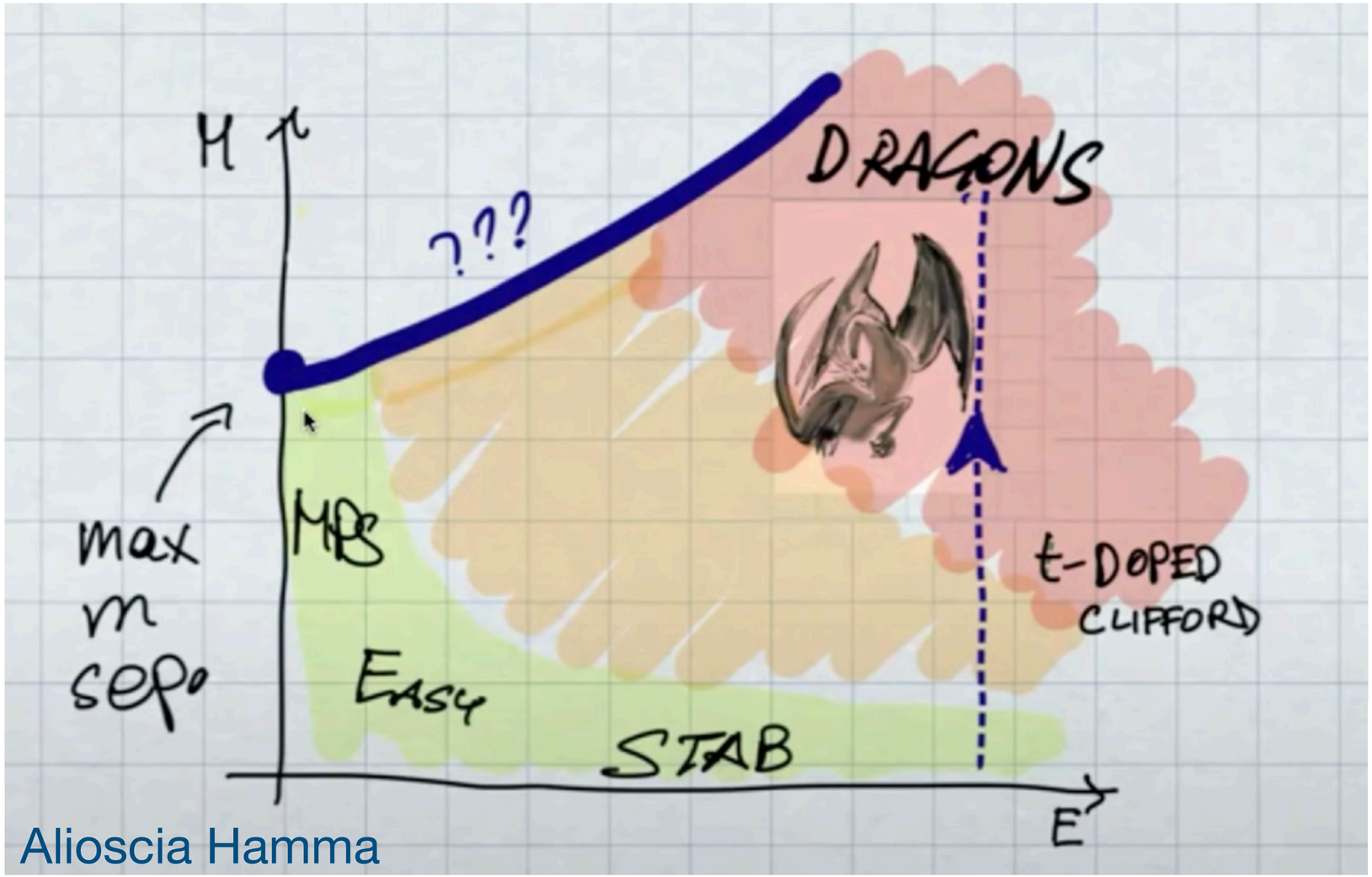
When is a Quantum Computer Required?

Quantum Complexity of Physical Systems?



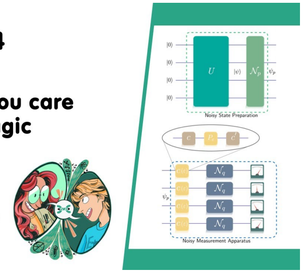
Magic

Entanglement

qmcts #4

Why should you care about Magic

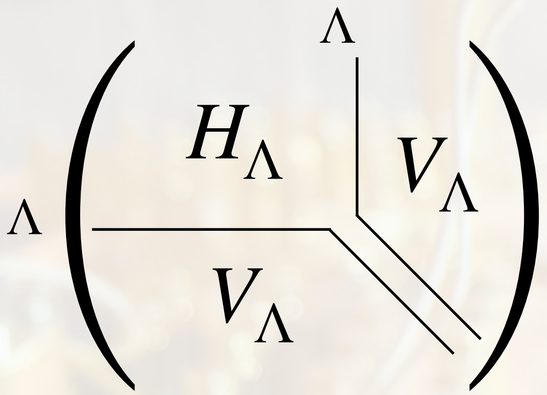
Prof. Alioscia Hamma
Dr. Salvatore F.E. Oliviero



Hilbert fragmentation can be used to obtain a much tighter bound on truncation uncertainties

Ciavarella, Hariprakash, CWB, Halimeh, 2508.00061

Split U(1) Hamiltonian into two pices



Λ is chosen large enought that Hilbert space fragmentation occurs at that value

For U(1) gauge theory, we can plug the explicit matrix elements to find

$$\left|\left(e^{-i\hat{H}t} - e^{-i\hat{H}_\Lambda t}\right)|\phi(0)\rangle\right| \leq 2\ \max_{t<T}\left|\sum_{k=\Lambda_0}^{\Lambda}\left[\left(e^{-i2g^2(\Lambda+1)^2 t} - e^{-i2g^2k^2t}\right)\prod_{\substack{l=\Lambda_0\\ l\neq k}}^{\Lambda+1}\frac{1}{k^2-l^2}\right]\right|\left(\frac{1}{2g^2}\right)^{\Lambda-\Lambda_0}$$

$$\leq 2\left(\frac{1}{g^2}\right)^{\Lambda-\Lambda_0}\frac{(2\Lambda_0-1)!!}{(2\Lambda-1)!!}\left(\frac{1}{2g^2}\right)^{\Lambda-\Lambda_0}$$

IBM Heron results for 42 triangles and 72 petals

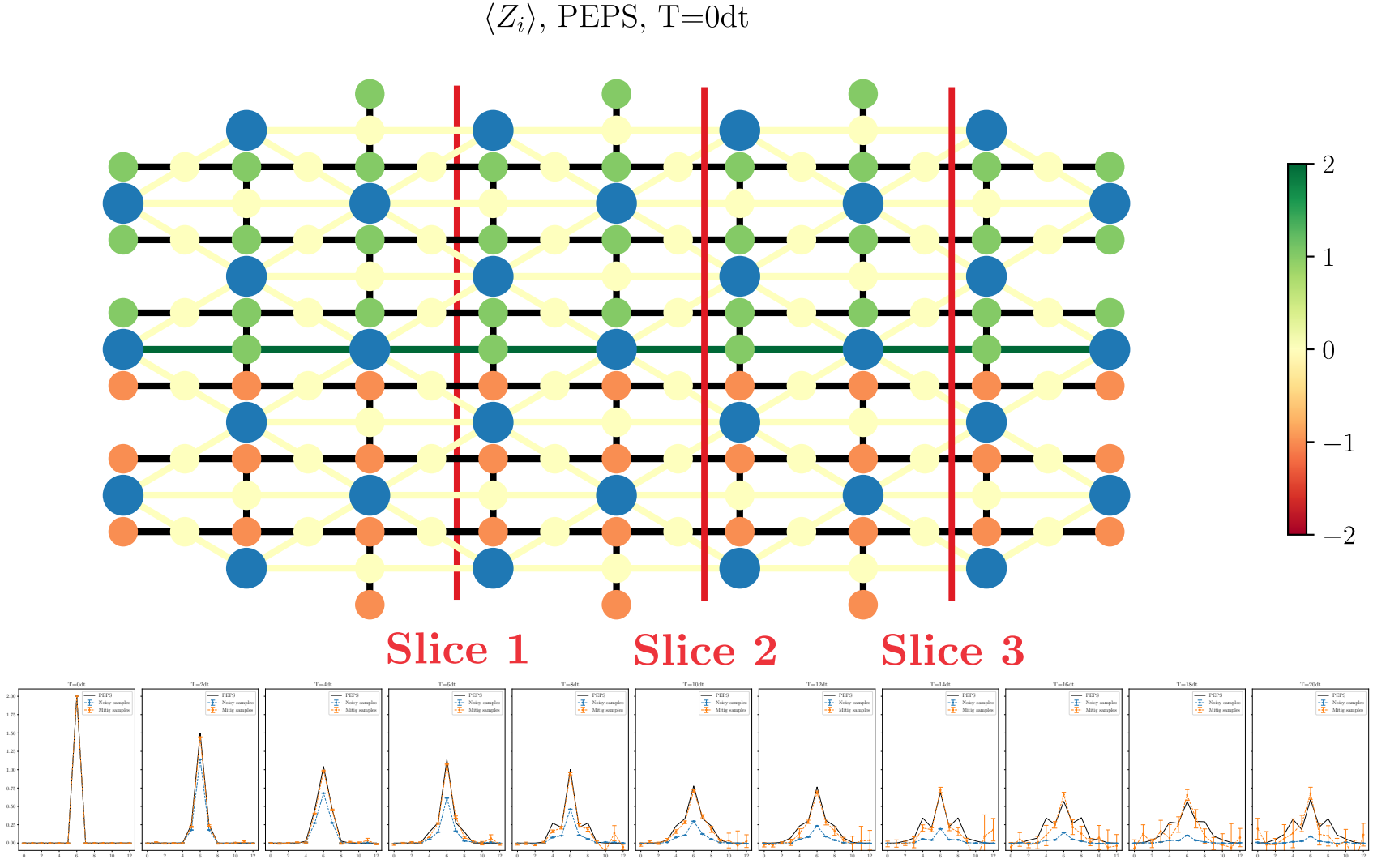
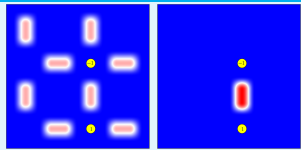


Figure: Lattice geometry of initial state and time evolution.

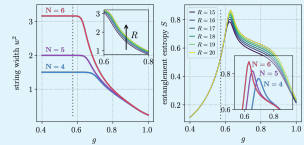
Tensor Networks for lattice field theories: beyond 1+1d

$\mathbb{Z}_3$ LGT in (2+1)d



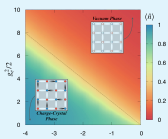
Robaina et al., Phy. Rev. Lett. **126**, 050401 (2021)

$\mathbb{Z}_2$ LGT in 2+1d



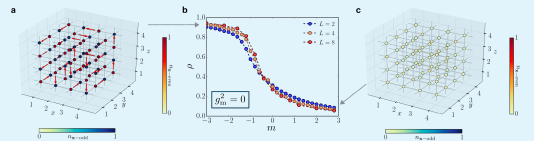
Di Marcantonio et al., arXiv:2505.23853
Xu et al., arXiv:2507.01950

U(1) Quantum Link Model in (2+1)d



T. Felser et al., Phys. Rev. X **10**, 041040 (2020)

U(1) Quantum Link Model in (3+1)d



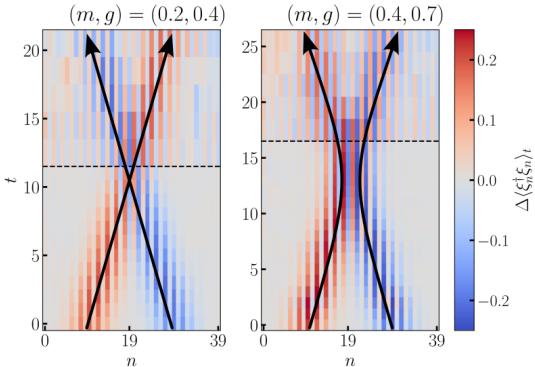
G. Magnifico et al., Nat. Commun. **12**, 3600 (2021)

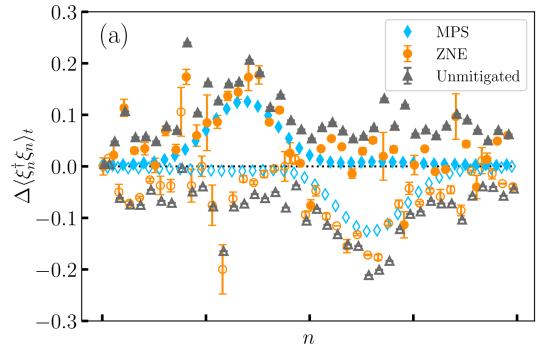
G. Magnifico, G. Cataldi, M. Rigobello, P. Majcen, D. Jaschke, P. Silvi, S. Montangero, Commun. Phys. **8**, 322 (2025)

Synergies with Quantum Computing

Tensor Networks for circuit compression: scattering in the Thirring model

> Simulation after compressing the initial part of the evolution and the time evolution operators



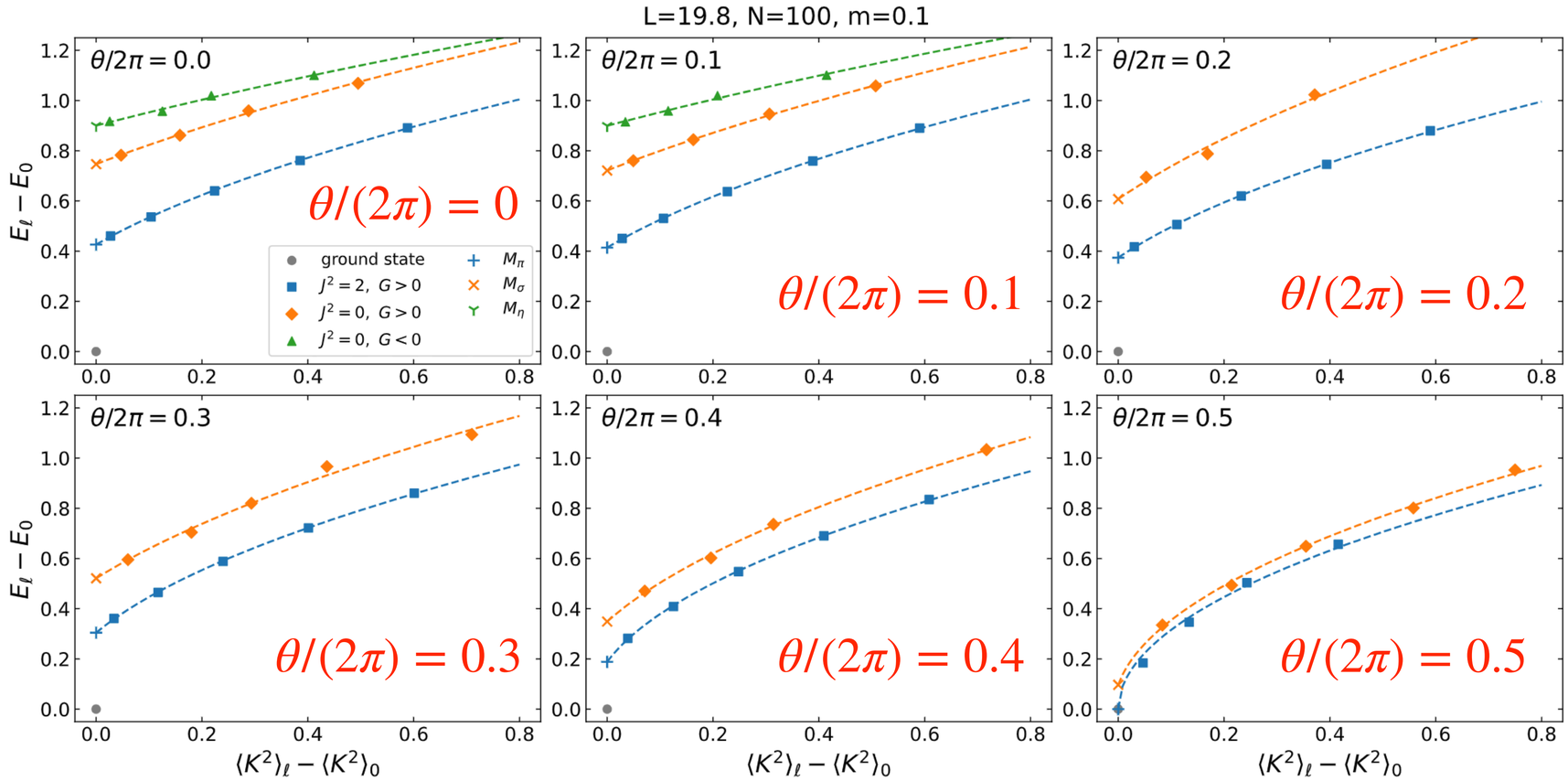


Y. Chai, J. Gibbs, V. R. Pascuzzi, Z. Holmes, SK, F. Tacchino, I. Tavernelli, arXiv:2507.17832

Dispersion-relation scheme in $\theta \neq 0$

E.I., Akira Matsumoto, Yuya Tanizaki, JHEP 09 (2024) 155

- Fit the data for each meson using $\Delta E = \sqrt{M^2 + b^2 \Delta K^2}$



eta meson

sigma meson

pion

η disappear $\theta/2\pi > 0.2$

sigma (singlet) and pion (triplet) are degenerating at $\theta = \pi$

The String Tension