

# Scaling of temporal entanglement and tensor network algorithms overcoming the entanglement barrier

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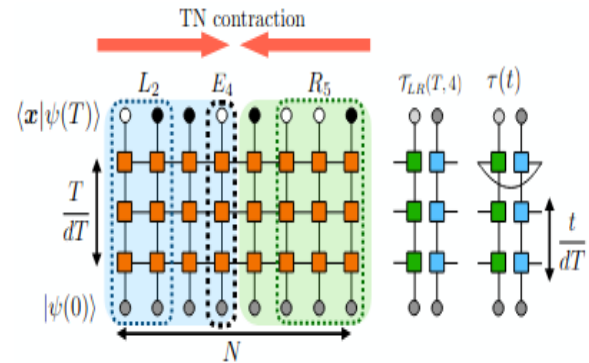
Abstract (Century Gothic 11)

Spatio-temporal tensor networks provide a new perspective on the out-of equilibrium dynamics [1]. After a short review, I will explain how they can be used to identify new universal phenomena out of equilibrium and a new tensor network algorithm which allow to overcome the entanglement barrier in simulating the Hamiltonian dynamics of 1D strongly correlated systems[2].

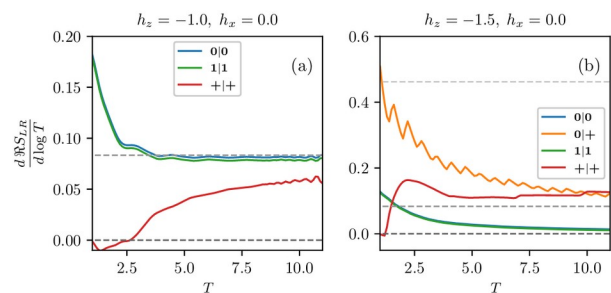
## References

- [1] *Spatio-temporal tensor-network approaches to out-of-equilibrium dynamics bridging open and closed systems* S Cerezo-Roquebrún A Bou-Comas J T. Schneider E Lopez L Tagliacozzo S Carignano Front. Quantum Sci. Technol., 12 May 2025
- [2] *Overcoming the entanglement barrier with sampled tensor networks* S Carignano, G Lami, J De Nardis, L Tagliacozzo arXiv:2505.09714 under review in PRX

## Figures



**Figure 1:** Tensor-network contraction for the wave function amplitude  $\langle x | \psi(T) \rangle$  with respect to a computational-basis state  $|x\rangle$ . Starting from the initial product state  $|\psi(0)\rangle = |x0\rangle$ , the system undergoes Trotterised evolution with  $T/dT$  steps of duration  $dT$ , each implemented by a Matrix Product Operator (MPO). At final time  $T$ , we project onto  $|x\rangle$ . Contraction proceeds by building environment tensors  $\langle L_i |$  (left of site  $i+1$ ) and  $|R_i\rangle$  (right of site  $i$ ), and by defining the transition matrix  $T_{LR}(T, i) = |R_i\rangle\langle L_i|$  and its reduced trace  $\tau(t)$ .



**Figure 2:** Universal growth of the temporal entanglement in time, identifying new universality classes.