Quantum information jet in the infinite temperature Hubbard model

Gergely Zaránd[1]
P. Penc,[1,2] M.A. Werner,[1,2] C.P. Moca,[1,3] M. Kormos,[1] Ö. Legeza,[2] T. Prosen[4]
[1]*Budapest University of Technology and Economics, Budafoki ut 8., H-1111 Budapest, Hungary*
[2]*Wigner Research Centre for Physics, H-1525, Budapest, Hungary*
[3]*University of Oradea, 410087, Oradea, Romania*
[4]*University of Ljubljana, Jadranska 19, SI-1000 Ljubljana, Slovenia*

Zarand.gergely.attila@ttk.bme.hu

In this presentation, I focus on the impact of interactions on quantum information generation within the infinite temperature Hubbard model. We study the formation and propagation of operator entanglement as well as mutual information in the presence of localized particle loss (sink) at the end of a semi-infinite Hubbard chain. We use a non-abelian approach to simulate this open system, while exploiting the SU(2)xU(1) symmetry of the Hubbard chain. In the non-interacting limit, a 3d quantization approach is used to benchmark our numerics.

The initial infinite temperature state has no entanglement. Incoherent loss at the end of the chain, however, amounts in a stream of particles towards the sink, accompanied by entanglement generation. A ballistic *depletion* and *current front propagation* is observed with *strongly reduced front velocity* in the presence of interactions.

In contrast, operator *entanglement* and *mutual information* are found to propagate *faster* than the depletion profile, and a mutual information jet appears that propagates with a velocity independent of U (see Figure 1).

The dynamics of the slow front can be captured quantitatively by a cellular automaton model, and is thus found to carry classical correlations. The fast mutual information front appears, in contrast, to have an intrinsic quantum-mechanical nature, and persists at infinite temperature and interaction. We understand the propagation of the fast front as being due to spinless fermionic excitations on the background of spinons.

References

[1] C.P. Moca, M.A. Werner, Ö. Legeza, T. Prosen, M. Kormos, G. Zaránd, Phys. Rev. B 105 (2022) 195144

[2] P. Penc, C.P. Moca, T. Prosen, G. Zaránd, M.A. Werner, arXiv:2402.19390 (submitted to Phys. Rev. Lett.)

Figures

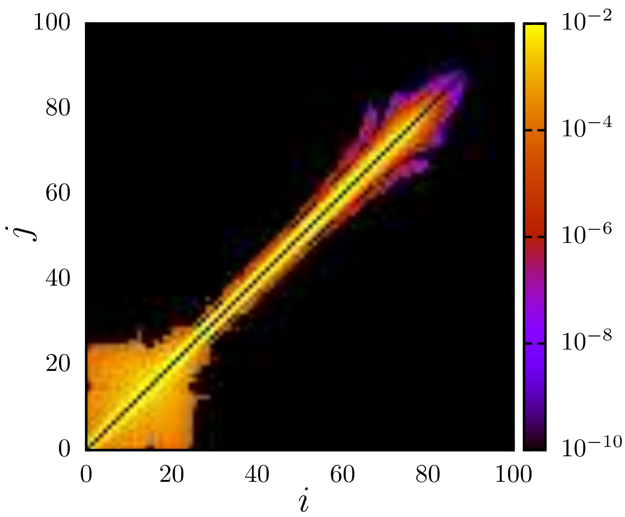

Figure 1:
Two-site mutual information, S(i,j), at time t = 80 for interaction U/J = 10. Long-range correlations appear for sites i,j ≲ 30, while a narrow, short-range correlated jet signal reaches i,j ≈ 80, and propagates with unrenormalized velocity.