Entanglement entropy of many-body systems with particle number conservation

Gregor Medoš[1,2] and Lev Vidmar[1,2]

[1] *Department of Theoretical Physics, Jožef Stefan Institute, Jamova cesta 39, Ljubljana SI-1000, Slovenia*
[2] *Department of Physics, Faculty of Mathematics and Physics, Jadranska ulica 19, University of Ljubljana, Ljubljana SI-1000, Slovenia*

Quantum entanglement in quantum many-body phyiscs is crucial in understading non-equilibrium dynamics and thermalization of closed systems, i.e., systems that are completely isolated from the environment. We can examine the bipartite entanglement entropy of quantum lattice systems of interacting bosons. The average entanglement entropy of highly excited eigenstates of a quantum chaotic Hamiltonian follows a volume law, described by Page's curve [1]. It has been shown in the hard-core boson limit that the presence of particle number conservation, the volume law term will depend on the average number of particles per lattice site [2]. The volume law leading term can be retrieved using a "mean-field" approach [3]. Using this approach we can explore soft-core bosons by generalizing the Bianchi-Dona distribution [4]. We manage to determine the volume law term of the average entanglement entropy for soft-core bosons using a generating function of the grand canonical ensemble at infinite temperature and a "mean-field" approach.

[1] Page, D. N. Physical review letters 71, 1291 (1993).
[2] Bianchi, E. et al., PRX Quantum 3, 030201 (2022).
[3] Vidmar, L. et al., Physical review letters 119, 220603 (2017).
[4] Cheng, Y. et al., Physical Review B 110, 235154 (2024).