

Entanglement entropy in quantum critical systems: from one to two dimensions

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Entanglement entropy has been recognized as a useful tool to analyze many-body ground states. Its novelty lies in its universal behavior reflecting the long-distance nature of the system. This has been highlighted in one-dimensional (1D) critical systems, where the entanglement entropy is related to the central charge of the underlying conformal field theory (CFT) [1]. The behavior of the entanglement entropy in two- and higher-dimensional critical systems is a challenging issue which receives growing interests. Here we discuss two situations where 1D viewpoints provide certain insights on this issue.

The first target is a critical Rokhsar-Kivelson wave function in two dimensions [2]. Although such a state appears as the exact ground state of a two-dimensional (2D) quantum model (say, a quantum dimer model), it is closely related to a 2D classical system. Using the transfer matrix technique, we relate the entanglement entropy of this wave function to a Shannon entropy of configurations in the ground state of a 1D quantum model. This connection significantly simplifies the analysis of the entanglement entropy. We find that the entanglement entropy obeys a linear scaling with the boundary length, followed by a universal subleading constant. In particular, if the 2D classical or 1D quantum system is described by a $c = 1$ bosonic field theory, this constant is expressed as a function of the boson compactification radius.

The second target is a system of two coupled Tomonaga-Luttinger liquids (TLL) on parallel chains [3]. We argue that the entanglement entropy defined between the two chains obeys a linear scaling with the chain length, and that the subleading constant is determined by the ratio of the two TLL parameters. We discuss the implications of this result on a sliding TLL, which appears in a 2D array of coupled TLLs.

References

- [1] P. Calabrese and J. Cardy, J. Stat. Mech. (2004) P06002.
- [2] J.-M. Stéphan, S. Furukawa, G. Misguich, and V. Pasquier, Phys. Rev. B **80**, 184421 (2009).
- [3] S. Furukawa and Y.B. Kim, preprint arXiv:1009.3016.