Holographic Branching and Entanglement Renormalization

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Entanglement renormalization [1] is a coarse-graining transformation for quantum lattice systems. It produces the multi-scale entanglement renormalization ansatz (MERA) [2], a tensor network state used to represent ground states of strongly correlated systems in one and two spatial dimensions [3, 4]. In 1D, the MERA is known to reproduce the logarithmic violation of the boundary law for entanglement entropy, $S_L \approx \log L$, characteristic of critical ground states. In contrast, in 2D the MERA strictly obeys the entropic boundary law, $S_L \approx L$, characteristic of gapped systems and a class of critical systems. Therefore a number of highly entangled 2D systems, such as free fermions with a 1D Fermi surface, Fermi liquids and spin Bose metals, which display a logarithmic violation of the boundary law, $S_L \approx L \log L$, cannot be described by a regular 2D MERA.

It is well-known that at low energies, a many-body system may decouple into two or more independent degrees of freedom (e.g. spin-charge separation in 1D systems of electrons). In this talk I will explain how, in systems where low energy decoupling occurs, entanglement renormalization can be used to obtain an explicit decoupled description. The resulting tensor network state, the *branching MERA* [5], can reproduce a logarithmic violation of the boundary law in 2D and, as additional numeric evidence also suggests, might be a good ansatz for the highly entangled systems with a 1D Fermi (or Bose) surface mentioned above. In addition, after recalling that the MERA can be regarded as a specific (discrete) realization of the holographic principle [6], we will see that the branching MERA leads to exotic holographic geometries.

References

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