Entanglement Entropy & Area Law

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Definition: The entanglement entropy is defined with respect to two systems A and B, and is given by the van Neumann entropy for the reduced density matrix:

$$S_A = -Tr_A(\rho_A log(\rho_A))$$

The entanglement entropy is a measurement for the strength of entanglement between two systems.

Behavior of the Entanglement Entropy:

Gapped Systems:

Entanglement entropy is proportional to the shared boundary of the two systems (Area law).

$$S_A \propto \partial A$$

Gapless Systems:

Entanglement entropy has a logarithmic correction.

$$S_A \propto log(l)$$

Deviations for the topological spin liquids which scale with the area law plus a topological entropy constant.

Area law: Unlike the classical entropy which is extensive, the area law postulates a proportionality of the entanglement entropy to the boundary of the two systems for the ground state.

Topological Entanglement Entropy: Indicates topologically ordered phases not 'seen' by local order parameters. These phases are useful for memory in quantum computation.

Notes: