Tensor Network and black hole

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Tensor Network

Tensor Network: Graphical representation of the wave function

Wave function of n-particle system

\[ |\psi\rangle = \sum_{\{s_j\}} C^{s_1 s_2 \cdots s_n} |s_1 s_2 \cdots s_n\rangle \]

Tensor Network

Scalar: \( C \)

Vector: \( C^{s_1} \)

Matrix: \( C^{s_1 s_2} \)

n-rank tensor: \( C^{s_1 s_2 \cdots s_n} \)
n-particles system in quantum critical system

Ground state wave-function can be approximately written as a special tensor network called MERA (Multi-scale entanglement renormalization ansatz) (G.Vidal:2007)

Wave function in critical phase

\[ |\psi\rangle = \sum_{\{s_j\}} C^{s_1 s_2 \cdots s_n} |s_1 s_2 \cdots s_n\rangle \]
Similarity between AdS space and MERA

MERA network $\rightleftharpoons$ a discrete version of AdS space

(B. Swingle, 2009)

MERA: graphical representation of the ground state wave function in the critical phase

Anti de Sitter (AdS) space

by M. C. Escher
MERA at thermal system and AdS Black Hole

By using Thermo Field Dynamics (Y. Takahashi and H. Umezawa, 1975), we suggest the following MERA at thermal system corresponds to the AdS black hole.