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Entanglement of Valence Bond Solid States in Different Topologies

The valence bond solid (VBS) state is the ground state of the Affleck-Kennedy-Lieb-Tasaki (AKLT) spin model, which has recently been proved to be the universal resource for measurement-based quantum computation, e.g., the spin-2 AKLT state on the square lattice. The VBS state is defined on various two-dimensional (2D) lattice structures with open and close (periodic) boundary conditions resulting in different topologies such as cylinder and torus, respectively. The AKLT state is derived by using the tensor network state for 2D lattices, specifically the projected entangled pair state (PEPS) approach. Although the AKLT model can be constructed on arbitrary lattice, the spin-$\frac{3}{2}$ and the spin-2 which are formed on the hexagonal and square lattices, respectively, are studied in this work. Entanglement of the system is investigated by equally bipartite partitioning and scaling the total number of sizes to measure the von Neumann entropy. The entanglement values of both systems, spin-$\frac{3}{2}$ and spin-2, in the thermodynamic limit show the exponential decay behavior approaching the saturated value for the case of the open boundary condition, but increase as the logarithmic behavior in the case of the close one.

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