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**Efficient simulation of infinite tree tensor network states on the Bethe lattice**[1] WEI LI, JAN VON DELFT, Physics Department, Arnold Sommerfeld Center for Theoretical Physics, and Center for NanoScience, Ludwig-Maximilians-Universität, 80333 Munich, Germ, TAO XIANG, Institute of Physics, Chinese Academy of Sciences, P.O. Box 603, Beijing 100190, China — We show that the simple update approach proposed by Jiang et al [H.C. Jiang, Z.Y. Weng, and T. Xiang, Phys. Rev. Lett. **101**, 090603 (2008)] is an efficient and accurate method for determining the infinite tree tensor network states on the Bethe lattice. Ground state properties of the quantum transverse Ising model and the Heisenberg XXZ model on the Bethe lattice are studied. The transverse Ising model is found to undergo a second-order quantum phase transition with a diverging magnetic susceptibility but a finite correlation length which is upper-bounded by $1/\ln(q-1)$ even at the transition point ($q$ is the coordinate number of the Bethe lattice). An intuitive explanation on this peculiar "critical" phenomenon is given. The XXZ model on the Bethe lattice undergoes a first-order quantum phase transition at the isotropic point. Furthermore, the simple update scheme is found to be related with the Bethe approximation. Finally, by applying the simple update to various tree tensor clusters, we can obtain rather nice and scalable approximations for two-dimensional lattices.

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