Entanglement in quantum critical spin systems in one and more dimensions

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We present an extensive study of entanglement properties in easy-plane quantum spin systems with a quantum phase transition driven by a magnetic field applied in the easy plane. Making use of quantum Monte Carlo simulations, we are able to monitor the behavior of englement in the ground state and at finite temperature as a function of the applied field for different lattice geometries of the system. Our calculations focus on the entanglement of formation, quantified by the *one-tangle* [1] for the global entanglement of the system and by the *concurrence* [2] for the pairwise englement. For the case of a one-dimensional spin chain, we observe that the entanglement estimators are able to single out with high precision both the quantum critical point, through a minimum of the paiwise-to-global entanglement ratio, and the known occurrence of a factorized state below the critical field, through the vanishing of all entanglement estimators [3]. The vanishing of entanglement at a given field also persists at finite-temperature, so that the system displays a temperature-resistant *entanglement switch* effect. We then extend the same analysis to the case of a spin ladder and of a square lattice, and, thanks to the entanglement estimators, we find that the existence of a factorized state close to the quantum critical point is a general feature independent of the geometry.

[1] V. Coffman, J. Kundu, and W. K. Wootters, *Phys. Rev. A* 61, 053206 (2000).

[2] W. K. Wootters, *Phys. Rev. Lett.* 80, 2245 (1998).

[3] T. Roscilde, P. Verrucchi, A. Fubini, S. Haas, and V. Tognetti, cond-mat/0404403.