Multipartite Entanglement Signature of Quantum Phase Transitions

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We derive a general relation between the non-analyticities of the ground state energy and those of a subclass of the multipartite generalized global entanglement measure defined by Thiago. R. de Oliveira, Gustavo Rigolin, and Marcos C. de Oliveira in [Phys. Rev. A 73, 010305(R) (2006)] for many-particle systems. We show that the generalized global entanglement signals both a critical point location and the order of a quantum phase transition. We also show that generalized global entanglement allows us to study the relation between multipartite entanglement and quantum phase transitions, suggesting that multipartite but not bipartite entanglement is favored at the critical point. Finally, using generalized global entanglement we were able, at a second order quantum phase transition, to define a diverging entanglement length in terms of the usual correlation length. We exemplify this with the XY spin-1/2 chain and explicitly show for this model that the entanglement length is half the correlation length.