Entanglement in Ising model

Peter Štelmachovič[1] and Vladimír Bužek[1,2]

[1] *Research Center for Quantum Information, Institute of Physics, Slovak Academy of Sciences, Dúbravská cesta 9, 845 11 Bratislava, Slovakia*

[2] *Department of Mathematical Physics, National University of Ireland, Maynooth, Co. Kildare, Ireland*

Interaction between spin-1/2 particles in general leads to quantum entanglement. We investigate the Ising model in a transverse field with the aim to determine the strength of the bi-partite entanglement (quantified in terms of concurrence) between spin-1/2 particles (qubits) as a function of the coupling constant. We present analytic calculations for arbitrary number of spins in the systems. We show that some of the eigenstates (not only the ground state) of the Ising Hamiltonian exhibit interesting properties around the critical point. For instance, bi-partite correlations do vanish while intrinsic N-partite correlations do appear in the system. In addition, we show that there is the eigenstate of the Hamiltonian such that two arbitrarily chosen subsets of k and $N-k$ spins ($k < N/2$) of the total number of spins are maximally entangled. This state can be transformed by local transformations into a product of k Bell pairs.