

Simulation of Quantum Adiabatic Search in the Presence of Noise

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Abstract

Results are presented of the most detailed simulation of the quantum adiabatic search algorithm in the presence of noise that has been carried out to date. The algorithm is applied to the NP-Complete problem N-Bit Exact Cover 3 (EC3). The noise is assumed to Zeeman-couple to the qubits and its effects on the algorithm's performance is studied for various levels of noise power, and for 4 different types of noise polarization. We determine the scaling relation between the number of bits N (EC3 problem-size) and the algorithm's noise-averaged median run-time $\langle T(N) \rangle$. Clear evidence is found of the algorithm's sensitivity to noise. Two fits to the simulation results were done: (1) power-law scaling $\langle T(N) \rangle = aN^b$; and (2) exponential scaling $\langle T(N) \rangle = a[\exp(bN) - 1]$. Both types of scaling relations provided excellent fits, although the scaling parameters a and b varied with noise power, and with the type of noise polarization. The sensitivity of the scaling exponent b to noise polarization allows, for the first time, a determination of which noise polarizations are most problematic for quantum adiabatic search. At sufficient noise power one expects a quantum computer to crossover to classical behavior, and the NP-like exponential scaling to provide a better fit than the P-like polynomial scaling (assuming $P \neq NP$). We may be seeing first signs of this crossover in our results, though further simulations at higher noise power are needed to properly address this question.