

Quantum Zeno effect versus adiabatic quantum computing and quantum annealing

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For the adiabatic version of Grover's quantum search algorithm as proposed by Roland and Cerf, we study the impact of decoherence caused by a rather general coupling to some environment. For quite generic conditions, we find that the quantum Zeno effect poses strong limitations on the performance (quantum speed-up) since the environment effectively measures the state of the system permanently and thereby inhibits or slows down quantum transitions. Generalizing our results, we find that analogous restrictions should apply universally to adiabatic quantum algorithms and quantum annealing schemes which are based on isolated Landau-Zener type transitions at avoided level crossings (similar to first-order phase transitions). As a possible resort, more gradual changes of the quantum state (as in second-order phase transitions) or suitable error-correcting schemes such as the spin-echo method may alleviate this problem.