Increase of entropy in chaotic many-body systems: can chaos destroy a quantum computer?

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Highly excited many-particle states in many-body systems (atoms, nuclei, quantum dots, spin systems) can be presented as "chaotic" superpositions of shell-model basis states. Indeed, the number of combinations to distribute n particles over m orbitals is exponentially large ($m!/(n!(m-n)!)$ in a Fermi system, 2^n in spin systems). Therefore, the interval between the many-body levels D is exponentially small and the residual interaction between the particles mixes a huge number of basis states (Slater determinants, products of spin or qubit states) when forming eigenstates.

Time dynamics of wave functions and increase of entropy in finite many-body systems is considered in a case when the eigenstates of these systems are "chaotic". As an example we consider the time evolution in a "closed quantum computer". A time scale for the entropy S increase is $t_c \sim \tau_0/(n \log_2 n)$ where τ_0 is the qubit "lifetime", n is the number of qubits. At $t \ll t_c$ $S \sim t^2 n J^2 \log_2 1/t^2 J^2$ where J is the interaction strength. At $t > t_c$ one has to struggle against the second law of thermodynamics since the number of "wrong" states increases exponentially as $2^{S(t)}$. Therefore, t_c may be interpreted as a maximal time for operation of quantum computer. At $t \gg t_c$ the system entropy approaches that for chaotic eigenstates.