Simplex Method of Creating Pseudo Pure State for NMR Quantum Computer while Concurrently Correcting Error

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Abstract

For NMR quantum computer, pseudo pure state is usually used as an initial state instead of pure state, however, when the number of qubits is large, it becomes difficult due to the decoherence and dissipation effects. In this work an efficient method of creating pseudo pure state for a large number qubit system is proposed.

There are predominantly two ways to prepare pseudo pure state from the thermal equilibrium state of nuclear spins. One is known as temporal averaging method, which can be expressed as a sum of unitary transformations, and the other is spatial averaging method, which can be expressed as a series of unitary and non-unitary transformations. For the former method the number of steps increases exponentially with the number of qubits, so it is not efficient in large-qubit system. On the other hand, for the latter method it could be expected that the number of steps is directly proportional to the number of qubits. Indeed it is easy to show that a sequence of one type of gates creates pseudo pure state within a tolerance and then the number of steps is directly proportional to the number of qubits if the decoherence and the dissipation effects can be ignored. However, the length of the sequence becomes much longer than the former method, therefore, it will fail to initialize the large-qubit system due to the decoherence and the dissipation effects.

The present work aims to create pseudo pure state within a specified tolerance with a few types of two-qubit gates, and by using computer simulation it is shown that a sequence composed of two types of non-unitary two-qubits gate (controlled-projection gate) and controlled-not gate enables to initialize large-qubit system correcting the decoherence and the dissipation effects, and the experimental demonstration of this method is also performed precisely by using a five-qubit NMR quantum computer.

Key words: quantum computer; NMR; decoherence; pseudo pure state; error correction;

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