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Opening the possibility of realizing quantum computers

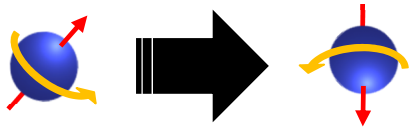
～Constant-step quantum circuits can compute the OR function～

Abstract

One of the main problems in realizing quantum computers is that the states of qubits, which represent the status of computation, change into unintended ones in a short time. This prevents us from implementing quantum algorithms correctly. Constant-step quantum circuits for the OR function are known to be quite useful for inventing techniques that address the problem. However, for over ten years, it has not been known whether such circuits can be constructed or not. In this work, we succeeded in constructing constant-step quantum circuits for various functions, including the OR function. In the future, these circuits will contribute to realizing quantum computers and thus to performing high-speed computation that cannot be done by today's computers.

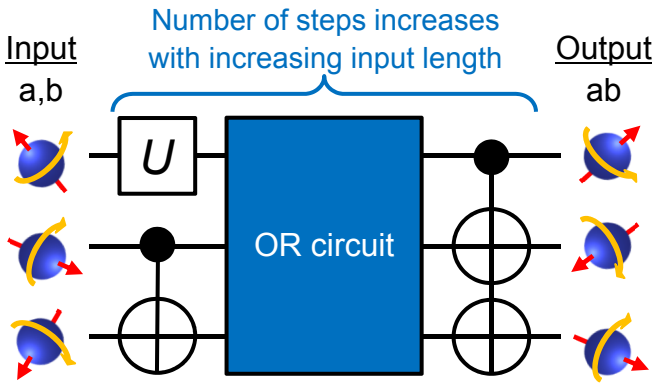
One of the main problems in realizing quantum computers

States of qubits unexpectedly change in a short time



Intended state　　Unintended state

Quantum circuit for multiplication



Input length increases → Number of steps increases
→ States of qubits unexpectedly change in the middle of computation

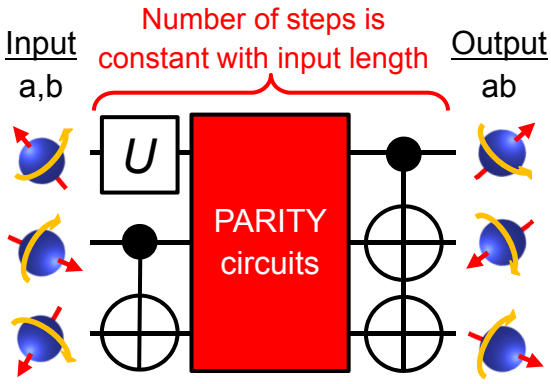
Our result

Constant-step quantum circuit for OR can be constructed

Application

Key idea: PARITY-based representation of OR

Constant-step quantum circuit for multiplication can be constructed



Input length increases → Number of steps is constant
→ Computation is completed before the states of qubits unexpectedly change

Related work

[1] Y. Takahashi, S. Tani, "Collapse of the hierarchy of constant-depth exact quantum circuits," in *Proc. 28th IEEE Conference on Computational Complexity (CCC2013)*, pp. 168-178, 2013.

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