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Suppressing gate errors through extra ions coupled to a cavity in frequency-domain quantum computation using rare-earth-ion-doped crystal SATOSHI NAKAMURA, HAYATO GOTO, MAMIKO KUJIRAOKA, KOUICHI ICHIMURA, Corporate RD Center, Toshiba Corporation, QUANTUM COMPUTER TEAM — The rare-earth-ion-doped crystals, such as Pr^{3+}: Y_2SiO_5, are promising materials for scalable quantum computers, because the crystals contain a large number of ions which have long coherence time. The frequency-domain quantum computation (FDQC) enables us to employ individual ions coupled to a common cavity mode as qubits by identifying with their transition frequencies. In the FDQC, operation lights with detuning interact with transitions which are not intended to operate, because ions are irradiated regardless of their positions. This crosstalk causes serious errors of the quantum gates in the FDQC. When resonance conditions between eigenenergies of the whole system and transition-frequency differences among ions are satisfied, the gate errors increase. Ions for qubits must have transitions avoiding the conditions for high-fidelity gate. However, when a large number of ions are employed as qubits, it is difficult to avoid the conditions because of many combinations of eigenenergies and transitions. We propose new implementation using extra ions to control the resonance conditions, and show the effect of the extra ions by a numerical simulation. Our implementation is useful to realize a scalable quantum computer using rare-earth-ion-doped crystal based on the FDQC.

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