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Realization of cross-talk avoided trapped-ion quantum network node with one ion species

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Quantum network is of great importance to the development of quantum communication, quantum computation and quantum metrology. With photon interference, separate quantum nodes can be entangled to build large-scale quantum information processor. However, its scaling up is facing with the challenge of quantum memory decoherence from photonic interfaces. To avoid disturbance, in trapped ion system, people are using two species of ions to work as the memory and communication qubits respectively, which at the same time boubled the complexity of the platform. Here, we use dual type qubits in one ion species to avoid crosstalk, which almost bring no increment to the system complexity. The $^2S_{1/2}$ clock state of $^{171}\mathrm{Yb}^+$ is used to generate ion-photon entanglement with the spontaneously emitted 369.5 nm single photon, working as the communication qubit, while the $^2F_{1/2}$ state works as the memory qubit. Within the time of a successful ion-photon entanglement generation, the information stored in memory qubit shows a fidelity of 83.56%, that about 14% of the infidelity comes from conversion and SPAM lose, and 3% from decoherence. In this way, we generate ion-photon entanglement successfully and prove that the entanglement attempts dose not effect the information stored in memory qubit.

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