Quantum Computation with Rotational States of Nonpolar Ionic Molecules

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All elementary building blocks necessary for construction of a quantum computer have been demonstrated over the past decade. However, scaling up to a larger number of qubits and raising the fidelity of qubit manipulation have remained big challenge. One of the most critical obstacle in accomplishing these missions is the decoherence problem. Thus, it is desirable to find out a new qubit system immune to decoherence.

We propose a novel quantum computer architecture which is robust against decoherence and scalable. As a qubit, we adopt rotational states of a nonpolar ionic molecule trapped in an ion-trap [1]. We show that the rotational-state qubits are much more immune to decoherence than the conventional electronic-state qubits of atomic ions. A complete method set for state preparation, single-qubit gate, controlled-NOT gate, and qubit-readout suitable for the rotational-state qubits is provided. Since the *ionic* molecules can be transported in an array of ion traps, the rotational-state qubits are expected to be a promising candidate to build a large-scale quantum computer.

Rotational states of nonpolar nonparamegnetic molecules are very robust against electromagnetic noise. We suggest NS_2^+ molecule as a suitable candidate whose rotational g-factor has a small value of -0.014. The tiny magnetic moment of the rotational-state qubit can greatly extend the coherence time, several orders longer than the conventional electronic-state qubits of atomic ions.

References

[1] S. J. Yun, and C. H. Nam, Phys. Rev. A **87**, 040302 (2013).