Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics

Objective

To study Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics

Summary of Research Activities

In quantum-optics experiments with both natural and artificial atoms, the atoms are usually small enough that they can be approximated as point-like compared to the wavelength of the electromagnetic radiation with which they interact. However, superconducting qubits coupled to a meandering transmission line, or to surface acoustic waves, can realize "giant artificial atoms" that couple to a bosonic field at several points which are wavelengths apart.

Here, we study setups with multiple giant atoms coupled at multiple points to a 1D waveguide. We show that the giant atoms can be protected from decohering through the waveguide, but still have exchange interactions mediated by the waveguide. Unlike in decoherence-free subspaces, here the entire multi-atom Hilbert space ($2N$ states for N atoms) is protected from decoherence. This is not possible with "small" atoms.

We further show how this decoherence-free interaction can be designed in setups with multiple atoms to implement, e.g., a 1D chain of atoms with nearest-neighbor couplings or a collection of atoms with all-to-all connectivity. This may have applications in quantum simulation and computing.

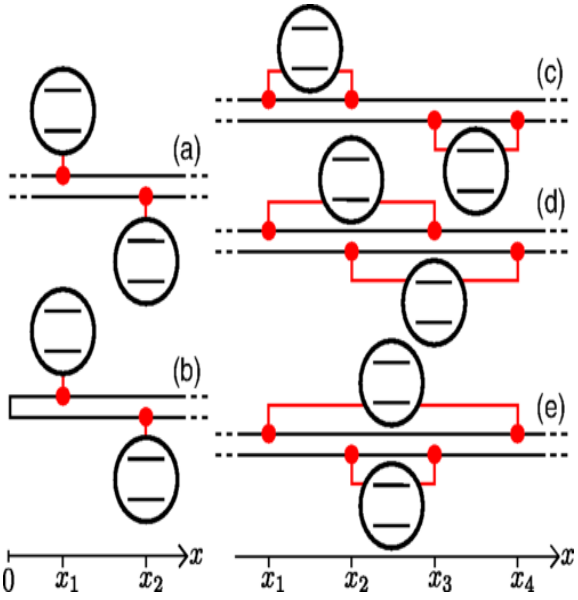

Fig. 1: Sketches of (a) two small atoms coupled to an open transmission line, (b) two small atoms coupled to a semi-infinite transmission line, (c) two separate giant atoms, (d) two braided giant atoms, and (e) two nested giant atoms. Red circles denote connection points. The atom with the leftmost connection point is denoted *a* and the other *b*.

Publications

A.F. Kockum, G. Johansson, F. Nori, *Decoherence-Free Interaction between Giant Atoms in Waveguide Quantum Electrodynamics,* Phys. Rev. Lett. **120**, 140404 (2018).
[PDF][Link][arXiv][Suppl. Info.]