Quantum Information Processing with Magnetically Trapped BECs in Cavity QEDs

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We propose in a new type of architecture for quantum information processing that based on the interaction of magnetically trapped ultracold quantum degenerate gases, such as atomic Bose-Einstein condensates (BECs), with external optical fields. Ultracold quantum gases are an interesting alternative as a realization of quantum memory, where a macroscopic number of atoms store quantum information. It has been shown recently that such systems can be used as effective qubits, and can be directly used to store and manipulate information [1,2] In our work we use permanent magnetic traps to trap the atoms, which has the advantage of negligible technical noise, and thus decoherence, in comparison to more conventional current-carrying-wire based methods[3] Several such nodes can be designed on the same device, realizing an array of trapped BECs. In order to communicate between various nodes, silica based waveguides are coupled to the atoms, by the use of microcavities centered around the magnetic traps. The proposed design allows the delivery of the optical fields (control/probe) to the trapped atoms through fabricated silica waveguides coupled to micro-cavities. Entanglement can be initiated between several cavities whenever an optical quantum bus is established on-demand by laser pulses between nodes as desired. We give a detailed derivation of the entanglement generation scheme and estimate the necessary experimental conditions for a working device.

Section: DV - Devices

Keywords: Atomchip, Bose-Einstein Condensate, Quantum Information Processing, Permanent magnetic traps

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