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TITLE: Optical lattice chip technology and quantum computation

ABSTRACT:

For quantum information processing to become more efficient than classical computation, we are required to coherently manipulate many qubits with a high degree of accuracy. However, it is very difficult to isolate a quantum mechanical system containing many qubits from its environment (which might affect in an uncontrolled way the evolution of the system), without losing the ability to manipulate its state. Recently, we have witnessed rapid development of trapping and manipulating technology of cold matter which can be mounted on miniaturised chip structures, the "atom chips". These offer the great advantage of having well ordered systems with up to a few million atoms in regular lattice structures cooled down to very low temperatures, close to their vibrational ground state. These are achieved by transitions of Bose-Einstein condensates to the Mott insulator phase of atomic Fock states.

The technological development of atom chips is ideal for the realisation of quantum computation with many qubits if the decoherence problem can be overcome. This requires the development of new strategies for the state manipulation of open quantum systems and the application of recently developed techniques from quantum optics as the employment of decoherence free subspaces. Sources for decoherence of the system are spontaneous emission from the atoms as in quantum optics as well as actual losses of atoms. In addition, problems arise from cooperative interactions between the atoms as well as other effects due to the size of the sample. We attack these problems by combining the geometrical setup of optical lattices in the engineering of the decoherence free subspaces. Furthermore this makes atom chips an interesting arena for modelling future implementations of quantum information in solid state systems.