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Collective qubits and hybrid schemes for quantum computing

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Abstract

In conventional registers for quantum information processing, quantum bits are associated with individual two-level quantum systems. Separate addressing and interaction with these systems permit one-bit gates, while an interaction between systems is needed to accomplish two-bit gates. I will discuss recent proposals to implement quantum computing in collective excitation degrees of freedom in ensembles of identical quantum systems. In this proposal one does not need to address individual particles, but one needs an interaction between all particles in the system.

Collective qubits have become increasingly attractive because they may couple strongly to other quantum systems, such as light modes and mesoscopic quantum systems. They can thus be applied in hybrid architectures, where, e.g., atoms are used as long-time memories while superconducting circuit elements can serve as fast, but short-lived, processing registers. We will review recent theoretical and experimental progress with large spin-ensembles, coupled to superconducting qubit elements via a resonant single mode of the quantized radiation field.