Quantum processing made easier with a little help from bosons

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The circuit model for quantum computation is usually invoked under the assumption that the gates are controlled by classical fields, though in some cases coupling to a quantized bosonic mode can simplify processing, a notable example being the Mølmer-Sørenson gate used for entangling trapped ions. In this talk I'll describe two recently developed techniques for quantum processing with the assistance of control on bosonic modes. The first uses a highly non-linear geometric phase gate enabled by dispersive coupling between spins and a boson which allows for exact synthesis of unitaries in the maximally symmetric space of qubits. This can be used for processing in permutation invariant quantum codes with applications to error corrected quantum sensing using so called gnu states. The second utilizes a Jaynes-Cummings type interaction between spins and a boson combined with a shaped pulse off-resonantly driving the mode and dissipation to realize non-local two qubit or many qubit gates. The latter has applications to processing in quantum error correction codes with low overheads.