The Cooper Pair Box as a realization of a qubit

The fundamental property of superconductors, that off-diagonal long-range order leads to the formation of a coherent state (the superconducting order parameter, Ψ) of all quasi-particle charge carriers in a sample, can be exploited to create the basis for quantum information processing. All schemes to do so currently make use of a non-linear tunneling barrier known as a Josephson junction. Perhaps the simplest, the Cooper Pair Box (CPB) uses a gate bias (V_g) to control the charge state of an isolated circuit element across a fate capacitance (C_g). The charge states are quantized in units of 2e, the Cooper pair charge, and the CPB can operate in a regime where only the two lowest approximately degenerate states are relevant. Since the qubit is a circuit element, readout and gate operations are particularly simple and fabrication is straightforward thanks to lithography techniques. However, material defects, stray electromagnetic fields, residual thermal noise and back-action of the readout circuit on the qubit are problematic. Despite these difficulties, the CPB is the most promising candidate among superconducting devices for a viable qubit scheme, having demonstrated, among other achievements, Rabi oscillations, successful DC readout and RF coupling of multiple junctions.