Control and decoherence of a quantum bit circuit

D. Esteve

Quantronics group, SPEC CEA-SACLAY, France.

The discovery about ten years ago of powerful quantum algorithms has triggered an intense research of physical systems in which the basic building blocks, the quantum bits, could be implemented. Among the solid-state devices, superconducting circuits are presently the most advanced. I will describe these circuits, and I will report experiments on the quantronium [1], which is based on small Josephson junctions. We have demonstrated that NMR methods can be efficiently used for manipulating the state of the quantum bit, and we have shown that arbitrary transformations of the quantum bit can be implemented by combining microwave pulses [2]. In order to investigate decoherence mechanisms acting in the quantronium, we have developed new experimental methods and a simple general framework. We have also developed different strategies in order to fight decoherence.

[1] D. Vion et al., Science 296 (2002).
[2] E. Collin et al., cond-mat/0404503 to appear in Phys. Rev. Lett.
.

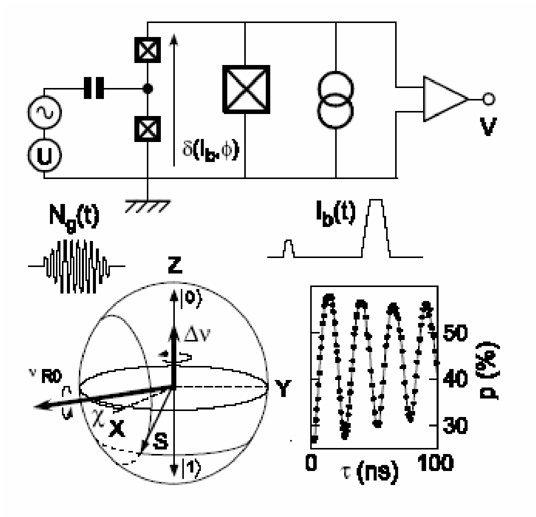

Fig 1: top: circuit diagram of the quantronium. The Hamiltonian is controlled by two parameters: the charge coupled to the box island between the two small junctions, and the phase across their series combination. The qubit state is manipulated by applying resonant microwave pulses, or adiabatic pulses on the control parameters. The oscillations of the switching probability of the readout junction reveal the Rabi oscillations of the qubit state.

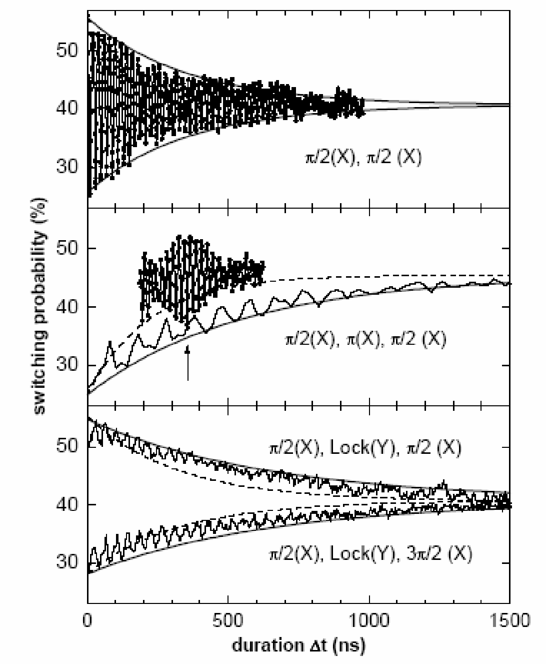

Fig. 2: Top : switching probability (dots) after a Ramsey {π/2(X), π/2(X)} sequence as a function of the time delay between pulses. Fits of the envelope (time constant 350 ns). Middle: example of echo measured in a {π/2(X), π(X), π/2(X)} sequence. Thin line: echo signal at the nominal minimum position. bold line: exponential fit of the envelope (550 ns time constant). dashed line: fit of the lower envelope of the Ramsey pattern measured in the same conditions (220 ns time constant). Bottom: switching probability after two spin-locking sequences, as a function of the sequence duration. Thick lines: exponential fits of the envelopes, with time constant 650 ns. The dashed lines show a fit of the envelope of the Ramsey pattern measured in the same conditions (time constant : 320 ns).