

Flux and phase qubits: techniques of operation

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Recently, different types of qubits, all based on Josephson junctions, have been experimentally demonstrated. Flux [1,2], phase [3,4,5] and phase-charge [6] qubits have been operated as single devices, while charge qubits have also been used in an entangled couple, showing quantum-coherent behaviour [7] and operation as conditional gate [8]. Which one of the proposed qubits will be the most promising in view of the implementation in a practical quantum computer is still an open issue. The main points that concerns a feasible qubit system rely on the following features: the single qubit should have a long decoherence time, its writing and reading system must be simple, fast and should allow a one shot detectability with high efficiency. The single qubit, moreover, should allow a simple and switchable connection with one or more qubits to realize the core of a C-NOT gate.

In our talk we will present the system we have developed to realize single and coupled set of qubits. At present we have two systems that may operate as a phase and flux qubits. The flux qubit is an rf SQUID realized with standard Niobium trilayer technology, read by a hysteretic dc SQUID working as a one shot detector of the rf SQUID flux states. The hysteretic dc SQUID may operate also as a phase qubits, driven by short pulses of microwaves. On this system we made a set of measurements to show induced oscillations between the first two energy levels of the dc SQUID.

A third scheme to implement a flux qubit, where the reading system is integrated with the qubit has been realized and tested. We will present the main idea underlying the qubit design and some preliminary test on the system, showing the correct behaviour of the proposed device.

To realize an efficient coupling between flux qubits we have proposed and realized a switchable coupling making use of the variable inductance of a hysteretic dc SQUID driven by short pulses of current. This coupling transformer looks, at the moment, one of the most efficient schemes to implement a flux based c-not gate.

References

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