MAR11-2010-002661

Abstract for an Invited Paper
for the MAR11 Meeting of
the American Physical Society

DC-SQUID Quantum Non-Demolition Readout of Superconducting Flux Qubits

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Extracting state information from a quantum system is a central theme in quantum mechanics. As the process of state extraction by a detector implies system-detector entanglement, reverse action from the detector onto the quantum object can not be avoided. Consequently, detectors that minimise this back action are crucial. For superconducting flux qubits [1] commonly a DC-SQUID detector is used, either in an AC dispersive scheme or in a switching mode. The latter can be by AC bifurcation or by direct DC switching. The DC approach combines simplicity in use with complexity in dynamical behaviour. This complexity results from the fast Josephson phase dynamics and the significant generation of quasi-particles in the dissipative detector ON-state. This gave rise to the long-standing belief that it can not act as a "good" detector. This includes it to fail as a Quantum Non-Demolition (QND) detector, i.e. the preservation of the state of the quantum object after a state readout. In a recent experiment for relatively weak qubit-SQUID interaction strength [2] we investigated the detection properties of such a DC-switching SQUID, finding a remarkably good QND fidelity. This was achieved by shunting the SQUID by a low-value resistor, thus strongly suppressing the generation of quasi-particles. Also the detector ON-time was minimised to a few tens of ns using a nearby cryogenic amplifier. The QND-ness was obtained from measuring the correlation between two successive readouts, and found to reach 75% QND fidelity. The weak qubit-detector interaction leads to a limited readout contrast. We will discuss the results as well as its consequences, including the potential for combining high contrast and good QND fidelity.

[1] J.E. Mooij et. al., Science **285**, 1036 (1999)
[2] T. Picot et. al., Phys. Rev. Lett. **105**, 040506 (2010)