Final Report Project 015

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Within this project, I have applied for funding for visits at three SQUBIT partners. Parts of it has been reported in a previous report.

Report:

Visit 1: Delft, Sept. 2001 – short version of previous intermediate report

I have visited Delft from Sept. 21-25. In the first few days, I participated in the SQUBIT (Review and Scientific) meeting. I learned about the experimental progress on the "second generation" of superconducting qubits in Gothenburg and Saclay. The main innovation of this generation is an optimization of the measurement process. In the direction of a weak measurement with optimum signal / noise ratio. This can be contrasted with my own proposal of genuine and still realistically feasible *strong* measurements (paper submitted to PRB. I got a chance to present and discuss this idea at the meeting and stimulate the idea to consider this as an option for the new, third generation, experiments in this direction. The Saclay group has shown that it is feasible and achievable to read out a *charge* qubit through the *phase* channel, i.e. to the observable *conjugate* to the natural classical basis. At present, I am working this idea out with a visiting graduate student from Chalmers.

In the second half of my stay, I had a chance for intense discussion with the Delft group about their ongoing experiments. I could explain them the results of our simulations concerning higer-harmonics generation. Moreover, I learned about an observation of sub-harmonic generation.

Visit 2: Delft, Feb. 2002

I have visited Delft for a couple of days in order to finalize my work with Marlies Goorden, who now finished her studies and went on for PhD in the Beenakker group in Leiden. This project was mostly about interplay of driving and dissipation at low temperatures. In this project, we have developed a numerical tool which simulates single-qubit experiments. We have analyzed the dynamics of a driven qubit and its relation to spectroscopic data. We have shown, how to experimentally determine all relevant parameters of a qubit experimentally, which is very important for cryogenic experiments, where not even the strength of the applied field is known due to the massive filtering. We have generalized the usual linewidth formula to higher orders and have shown its limitations at strong driving, when T1 and T2 change from their undriven values. This work has lead to a paper which is presently in the review process.

During this visit, we have finalized the discussion of a manuscript on engineering decoherence in solid-state qubits, which was part of my postdoc project at Delft and which now has been published [1]. We have continued our discussion on optimum design criteria, which has contributed to the new Delft setup which has shown Rabi oscillations.

Visit 3: Saclay, December 2002

This visit was timed to coincide with the SQUBIT meeting. It provided a unique opportunity for me to (re)connect to the groups in SQUBIT. I learned about theoretical and experimental activities in the domain of coupled qubits, in which we are also working. Most prominently, we already had started to look at design criteria for superconducting switches as a side project. I learned on the meeting, that this is of high interest to many and deserves to be carried out to a larger extent. We are presently compiling our results on this issue into a paper.

Next to that, I had a chance to learn more about recent experimental activities in Delft and Chalmers and open questions connected to our previous theory of decoherence on the way to *quantitative* understanding.

It was highly exciting and stimulating to have exchange with the SQUBIT network and I wish to thank QUIPROCONE for funding this activity.

Deliverables

Published common papers

Engineering decoherence in Josephson persistent-current qubits
C.H. van der Wal, F.K. Wilhelm, C.J.P.M. Harmans, and J.E. Mooij
Eur. Phys. J. B **31**, 111 (2003), cond-mat/0211664

Published papers profiting from the project

Decoherence and gate performance of coupled solid state qubits
M.J. Storcz und F.K. Wilhelm, accepted for publication in Phys. Rev. A
cond-mat/0212374

Engineering the quantum measurement process for the persistent current qubit
T.P. Orlando, L. Tian, D.S. Crankshaw, S. Lloyd, C.H. van der Wal, J.E. Mooij, and F.K. Wilhelm
Physica C **368** 294 (2002)

Submitted papers

Theoretical analysis of continuously driven solid-state qubits,
M.C. Goorden and F.K. Wilhelm, submitted to Phys. Rev. B

Large Berry phase in gated persistent- current quantum bits
F.K. Wilhelm and J.E. Mooij
submitted to Europhys. Lett. , 7 pages

An asymptotical von-Neumman measurement strategy for solid-state quantum bits
F.K. Wilhelm
submitted to Phys. Rev. B, 4 pages

Papers in preparation

Design and noise properties of realistic switches for coupling superocnducting solid-state qubits
M.J. Storcz and F.K. Wilhelm, in preparation for Appl. Phys. Lett.