ESF SHORT VISIT GRANT

Awarded to: Astria Price, Physikalisches Institut III, Erwin-Rommel-Str 1, 91058 Erlangen, Germany.

Grant reference number: 1572.

PURPOSE OF THE VISIT

The aim of the visit was to finalise two manuscripts intended for joint publication with our collaborators Dmitry Gulevich and Prof. Feodor Kusmartsev from the Condensed Matter Theory and Quantum Information group at Loughborough University in Leicestershire, United Kingdom. The manuscripts combine experimental results obtained in Erlangen with the theoretical expertise of our colleagues in Loughborough, and deal with distinct but closely related areas of research on annular Josephson junctions: the microshort qubit, and the mechanism of switching to the resistive state.

1. Part of our collaborative work concerns the development of a vortex qubit based on an annular Josephson junction containing a microshort. Compared with types of superconducting qubit technologies, the vortex qubit is expected to offer longer coherence times, on the order of microseconds [1]. Aspects addressed in the manuscript include qubit design, operation and coupling. A novel microshort construction is investigated; since it is based on modulating the width of the junction, the microshort qubit can be produced in standard lithographic superconducting circuit fabrication processes, which are compatible with Rapid Single Flux Quantum logic.

2. Another mutual research interest is the conditions under which the switching of an annular junction to the resistive state results from homogenous phase switching in the form of classical string escape, rather than vortex-antivortex nucleation. Whereas phase escape is well described by the collective coordinate approach in long junctions, in shorter junctions one should view it as the homogeneous transition of a string object along the entire length of the junction. Measurements regarding the dependence of the switching mechanism on junction length are to be presented in the planned joint publication, which couples recent theoretical work [2] with extensive systematic experimental data.

[1] J.H. Kim, R.P. Dhungana and K. Park, Phys. Rev. B **73**, 214506 (2006).
[2] D. Gulevich and F. Kusmartsev, Physica C **435**, 87 (2006).

WORK CARRIED OUT DURING VISIT, AND MAIN RESULTS OBTAINED

A large portion of my time at Loughborough University was devoted to discussions with co-authors Dmitry Gulevich and Prof. Feodor Kusmartsev on two joint papers:

1. One publication will present theoretical and experimental work on the microshort qubit. Until recently, it was unclear why the depinning current of the vortex from the microshort was several times larger than predicted by the one-dimensional sine-Gordon model. I showed my Loughborough collaborators new data obtained in Erlangen which suggest the origin of this discrepancy, and we decided how to incorporate this information into our manuscript.

2. The second publication concerns the switching of an annular junction to the resistive state in dependence on its length. One difficulty in fitting our experimental data to theory on phase switching in the form of classical string escape has been uncertainty over the temperature dependence of the quasiparticle dissipation in the measured junctions. Together, we identified experimental means by which the assumed temperature dependence can be confirmed. I carried out preliminary measurements towards this end shortly after my return to Erlangen.

During my stay at Loughborough University I was pleased to deliver a talk entitled *Experimental realisation of a prototype superconducting microshort qubit*, as part of the *Quantum Information Seminar* series. I reported on measurements made to date in Erlangen regarding the development of the microshort qubit, to an audience of experts in Quantum Information theory. The ensuing lively discussion on the effects of experimental noise in our qubit prototype, and the inherent quantum nature of this qubit design, proved enlightening for numerous participants including myself.

FUTURE COLLABORATION WITH HOST INSTITUTION

While I was at Loughborough University Prof. Kusmartsev introduced me to Prof. Thomson from the Materials Research Group at the Institute of Polymer Technology and Materials Engineering. Prof. Thomson showed us the Institute's new and highly advanced electron-beam lithography system. We discussed the prospect of fabricating of annular Josephson junctions using this equipment. Electron-beam lithography offers the possibility of manufacturing ultra-narrow long Josephson junctions, for which the cross-over temperature to the quantum regime is correspondingly higher.

After my return to Erlangen, I sent Prof. Kusmertsev design files of annular Josephson juctions, as a first step towards their fabrication at Loughborough University.

PROJECTED PUBLICATIONS RESULTING FROM GRANT

We will publish two papers, with the following titles:

1. *A vortex qubit based on a dilated long Josephson junction*
2. *String escape in annular Josephson junctions of various lengths*

OTHER COMMENTS

I wish to thank the European Science Foundation for supporting me in my PhD research by enabling me to meet with long-time collaborators in person for the first time, as well as other researchers at the Loughborough University whose interests are similar to my own.