Notice of the Final Oral Examination for the Degree of Master of Science

of

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BSc (Carleton University, 2015)

“Non-Local Electrodynamics of Superconducting Wires: Implications for Flux Noise and Inductance”

Department of Physics and Astronomy

Wednesday, December 6, 2017
10:00 A.M.
Elliott Building
Room 160

Supervisory Committee:
Dr. Rogério de Sousa, Department of Physics and Astronomy, University of Victoria (Supervisor)
Dr. Reuven Gordon, Department of Electrical and Computer Engineering, UVic (Outside Member)

External Examiner:
Dr. Trevor Lanting, Experimental Physicist, D-Wave Systems Inc.

Chair of Oral Examination:
Dr. Raad Nashmi, Department of Biology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies
The simplest model for superconductor electrodynamics are the London equations, which treats the impact of electromagnetic fields on the current density as a localized phenomenon. However, the charge carriers of superconductivity are quantum mechanical objects, and their wavefunctions are delocalized within the superconductor, leading to non-local effects. The Pippard equation is the generalization of London electrodynamics which incorporates this intrinsic non-locality through the introduction of a new superconducting characteristic length, $\xi_0$, called the Pippard coherence length. When building nano-scale superconducting devices, the inclusion of the coherence length into electrodynamics calculations becomes paramount. In this thesis, we provide numerical calculations of various electrodynamic quantities of interest in the non-local regime, and discuss their implications for building superconducting devices.

We place special emphasis on Superconducting QUantum Inteference Devices (SQUIDs), and their usage as quantum bits (qubits) in quantum computation. One of the main limitations of these qubits is the presence of intrinsic noise, which leads to decoherence of the qubits. Although the origin of this noise is not known, there is evidence that it is related to spin impurities within the superconducting material. We present calculations which show that the noise in the non-local regime is significantly different from the local case. We also demonstrate that non-local electrodynamics greatly affect the self-inductance of the qubit.