Title and abstract of the 1995 PhD thesis of **Martin Brett Tarlie**
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Thesis title: **Nonequilibrium Properties of Mesoscopic Superconducting Rings**

Thesis abstract: In this thesis we study certain nonequilibrium properties of mesoscopic superconducting rings, i.e., rings of finite circumference. Two classes of nonequilibrium behavior will be considered: (i) the system is prepared in a nonequilibrium state and subsequently allowed to relax toward equilibrium, and (ii) the the system in contact with an external driving force that does not allow the system to relax toward equilibrium. In Chap. 2 we consider the problem of the decay rate of a persistent supercurrent. For the case of wires that are in the thermodynamic limit (i.e., not mesoscopic) the temperature and current dependence of the persistent -current lifetimes has been calculated. In this thesis we extend these results to include the dependence of the lifetime on the length of the wire. We find that as the length of the wire is reduced, the rate of decay, per unit length of the wire, decreases. Our calculation of the length-dependence of the lifetime of a persistent current enables a comparison of two distinct experimental configurations: the superconductor is driven by (i) a voltage source, and by (ii) a current source. We find that for systems driven by a voltage source, the length-dependent corrections to the lifetime of a current -carrying state are substantial, whereas, for the case of a current source, the lifetime does not acquire any substantial length-dependent corrections. This is an explicit example of the general result that for mesoscopic systems, i.e., systems that are not in the thermodynamic limit, the choice of the ensemble is not free. In order to calculate the lifetime of a persistent current, it is necessary to compute the ratio of determinants of differential operators, with all zero eigenvalues omitted. The process of factoring out the zero eigenvalues is known as regularization. The powerful formalism that has been developed for computing the determinants of differential operators including all of the eigenvalues (i.e., unregularized determinants), is extended to allow for computation of the regularized determinants in a form that is no more complicated than the computation of the unregularized determinant. Finally, we study the dynamics of the supercurrent near the critical supercurrent. We imagine that the ring is under the influence of an electric field of sufficient strength so that the current can be driven to the critical current, at which point the system becomes unstable. We find that for 'weak' electric fields, single phase-slip processes dominate, but as the field strength is increased there is a crossover to double phase-slip dominated behavior. These results lead us to consider the general problem of the decay from an unstable state when multiple metastable states compete for occupation. We present a possible approach, inspired by the Onsager-Machlup formalism and based on a path integral technique, to this problem.