A B S T R A C T

The equilibrium properties of a superconducting state are well understood and the current interest is focussed on the properties of superconductors which are not in thermal equilibrium state. These non-equilibrium properties are interesting in themselves from a physical point of view since many interesting phenomena occur which do not whow up in the equilibrium state superconductor. The proper understanding and interpretation of these non-equilibrium phenomomena is also of practical interest because when superconductors are used in various fields of applied Physics, they are often in states that deviate essentially from thermal equilibrium.

The non-equilibrium state can be created by external disturbance such as laser irradiation, microwave irradiation, phonon injection, quasiparticle injection, time dependent externally applied currents and thermal gradients. The strongly driven superconductors have all the three components (quasiparticles, phonons and pair field) significantly altered from their respective equilibrium values.

Contrary to the problems of thermal equilibrium state, the nonequilibrium state will not be a single state depending only upon a few variables such as, temperature,

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pressure, magnetic field. Rather, there will exist a variety of possible nonequilibrium states depending not only on how far the system is driven out of equilibrium, but also upon the specific nature of the external source that drives the superconductor. The system can also exhibit hysteretic behaviour.

The coexistance of superconductivity and the magnetic ordering is also of great current interest. The rare earth ternary compounds like $Er\,Rh_4\,B_4$ manifest the coexistance of superconductivity and Ferromagnetism. These have shown unusual and peculiar features which include the reentrant phase transition to a ferromagnetic normal state at the lower critical temperature T_{c2} which is in addition to the paramagnetic normal to superconducting transition at the upper critical temperature T_{c1}. The resistance-temperature characteristics of these reentrant ferromagnetic superconductors exhibit a curious but poorly understood thermal hysteresis in the vicinity of T_{c2}.

The temperature of magnetic ordering T_M does not coincide with the superconducting transition temperature T_{c2} but is approximately 0.05 K higher than T_{c2}, so that $Er\,Rh_4\,B_4$ compound has a naroow region between T_{c2} and T_M for the occurance of superconductivity and Ferromagnetism.

The thesis is organised as follows :

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In the first Chapter we introduce nonequilibrium superconductivity and discuss its various aspects. We build the concepts which are necessary for the understanding of the non-equilibrium-phenomena in superconductors.

In Chapter II, we represent the coupled kinetic equations for the quasiparticle distribution functions and their deviations from equilibrium. This is based on microscopic Green's functions technique. We give the Green's function formalism in Keldysh matrix form, and using the standard quassiclassical approximation derive the coupled kinetic equations. We then use the slow variation of space and time approximation to derive a generalised time dependent Ginsburg - Landau equation valid near T_C.

In Chapter III, we give an account of the phase slip centres (PSC) which are seen to occur in the superconducting quasi one dimensional filaments and whiskers. Some recent developments in the understanding of the PSC state are discussed. We also present our calculations of the nonequilibrium region in the PSC in the Indium Whiskers. Using the experimental data we estimate that the oscillating core of the PSC is of the order of 4 times the Ginsburg-Landau coherence length.

In Chapter IV we summarise the experimentally observed nonlinear-voltage characteristics of a thin film sample of

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the ferromagnetic superconductor $Er Rh_4 B_4$ at bath temperature below the lower critical temperature T_{c2}. Based on a systematic analysis of these I - V characteristics, we demonstrate that the non-equilibrium effects associated with the dissipative intermediate resistance state of the reentrant thin film superconductor can be adequately accounted for by a simple superconductor heating model. Furthermore, we find that the magnitude of the thermal boundary conductance of the film-substrate interface obtained from the present analysis is of the same order as that expected for Kapitza - like heat transfer between solids at low temperatures. The implications of these observations are discussed.

In Chapter V we suggest how a cyclindrical wire of a reentrant ferromagnetic superconductor immersed in a helium bath can serve as a good candidate for studying nonequilibrium superconductivity, by virtue of the fact that the thermal boundary transport in this case involves only a solid-fluid interface. We calculate the temperature distribution in cylindrical sample of reentrant superconductor $Er Rh_4 B_4$ carrying current in ferromagnetic resistance state. We find that the radial temperature distribution is nearly uniform throughout the cross-section of wire,

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loading to a simultaneous onset of a nonequilibrium intermediate resistance state in the entire cross-section of the wire at a critical power level. The results indicate that surface thermal transport dominates the current-voltage characteristics of the nonequilibrium reentrant superconductor. The significance of the findings for gaseous and liquid helium environments is also discussed.