ELECTRICAL AND THERMAL MAGNETO-TRANSPORT IN THE MIXED STATE OF HIGH Tc-SUPERCONDUCTORS

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Abstract

The electrical resistivity, thermoelectric power (or Seebeck effect) and thermal conductivity probe the charge and heat carrier currents caused by external electric and temperature gradients. When a magnetic field is additionally superimposed, phenomena called excess electrical resistivity, excess thermoelectric power, Nemst effect and excess electrothermal conductivity can be observed on superconducting samples. This allows one to supply some consistent information on the kinetics of vortices and of quasi particle scattering in the mixed state. It is shown from the electrical resistivity measured with a disk geometry that vortex and quasiparticle dissipations seem to have the same order of magnitude, in contrast to low temperature/conventional superconductors. Before analysing the Seebeck effect in a field, the zero field case should be appropriately understood with respect to having a grasp on the “background term”, in particular for semimetallic-like systems with several carrier bands. The field dependent electrothermal conductivity which is the ratio of the Seebeck coefficient to the electrical resistivity, is finally shown to contain the signature of the order parameter symmetry up to the critical temperature. Therefore much effort should be put on sorting out first the various dissipation mechanisms in the mixed state of superconductors if superconducting microwave devices (in a field) are envisaged. Moreover, it is of interest to have some further thought on the role that an anisotropic d-wave gap parameter can have on microwave properties and how its peculiar symmetry can be used in devices.

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1. Introduction.

The content of this contribution has the following aims: to point out that some effort should be put on sorting out the various dissipation mechanisms in the mixed state of high critical temperature superconductors (HTS). This can only be done by having a grasp on so-called background terms originating from the normal state situation extrapolated below the critical transition in zero field, and on the role that an anisotropic (d-wave most likely) gap parameter can play on e.g. microwave properties and other devices. In order to do so, I will describe recent measurements of the electrical resistivity in presence of a magnetic field perpendicular to the plane of a superconducting disk sample in Sect. 2. I will try to show that vortex and quasiparticle dissipation mechanisms can be disentangled, and moreover seem to have the same order of magnitude, in contrast to low temperature conventional superconductors. The other transport coefficient of interest is the thermoelectric power (or Seebeck effect). It probes the charge carrier currents caused by an external temperature gradient. I will briefly discuss in Sect. 3 that the Seebeck effect is far from understood in normal, simple systems, and alas sometimes wrongly analysed. When a magnetic field is additionally superimposed, the magneto Seebeck effect is of interest but needs some new approach through for example the excess thermoelectric power which can contain information both on the kinetics of vortices and of quasi particle scattering in the mixed state. The latter is usually neglected even though the thermoelectric power is a transport coefficient. I will mention in Sect. 4 the Nernst effect which is the equivalent of the Hall coefficient, but when a thermal gradient is imposed, and is thus a transverse magneto-thermal transport coefficient. In Sect. 5 I will briefly discuss the ratio of the Seebeck coefficient and the electrical resistivity in a field, i.e. the field dependent electrothermal conductivity. I will indicate that it contains the signature of the order parameter symmetry. In conclusion, in Sect. 6, I will suggest some thought on the relevance of such investigations for microwave devices.

2. Electrical resistivity of a superconducting disk in a transverse magnetic field.

The electrical current flowing radially from the center of a superconducting disk to its perimeter, i.e. the so-called Corbino geometry, results in a double action on the vortex motion when the applied magnetic field is perpendicular to the disk plane. On one hand, the depinned vortices are set into a nearly spiral motion in the plane of the disk due to a Lorentz force. Second, because the current density profile is non-uniform specific activation can result through the intrinsic weak links, resulting in a non negligible