Magnetic field effects in energy relaxation mediated by Kondo impurities in mesoscopic wires

G. Göppert[1*], H. Grabert[1], Y. M. Galperin[2], and B. L. Altshuler[3]

[1] Physikalisches Institut, Albert–Ludwigs–Universität,
Hermann–Herder–Straße 3, D–79104 Freiburg, Germany
[2] Department of Physics, University of Oslo, P.O. Box 1048, N-0316 Oslo, Norway
and Argonne National Laboratory, 9700 S. Cass Avenue, Argonne, IL 6043, USA
[3] Physics Department, Princeton University, Princeton, NJ 08544, USA
and NEC Research Institute, 4 Independence Way, Princeton, NJ 08540, USA
*georg@tfp1.physik.uni-freiburg.de

We study the energy distribution function of quasiparticles in short voltage biased mesoscopic wires in presence of magnetic impurities and applied magnetic field. The system is described by a Boltzmann equation where the collision integral is determined by coupling to spin 1/2 impurities. We develop a theory of the coupling of non–equilibrium electrons to dissipative spins. This theory is valid as long as the characteristic smearing of the steps in the energy distribution function, which depends both on the bias voltage and the location of the probe, exceeds the Kondo temperature. We further address the renormalization of coupling constants by non–equilibrium electrons. Magnetic field dependence of the energy relaxation rate turns out to be non–monotonous. For low magnetic field an enhancement of energy relaxation is found whereas for larger magnetic fields the energy relaxation decreases again meeting qualitatively the experimental findings by Anthore *et al.* (cond-mat/0109297). This gives a strong indication that magnetic impurities are in fact responsible for the enhanced energy relaxation in copper wires. Our theoretical results are in good agreement with the experiment at large bias voltages where the theory is applicable. At the same time, at small bias voltages there are substantial quantitative deviations. Furthermore, the concentration of the spins that follows from the energy relaxation for Cu seems to to be substantially higher than the concentration which one would estimate form weak localization (dephasing rate) measurements. Since the approach presented is valid only above Kondo temperature it does not apply to the related problem of weak localization at low temperature in equilibrium.

[1] G. Göppert, Y. M. Galperin, B. L. Altshuler, and H. Grabert, (cond-mat/0205220).