Spin Transport in Magnetic Materials: Monte Carlo Simulation

H. T. Diep[1]

Abstract: In this work, we study the spin resistivity as a function of temperature T of itinerant electron spins moving under an electric field across a film. The film consisting of a number of atomic layers and possesses a magnetic ordering due to the interaction between its localized spins on the lattice sites. The film has a transition at a temperature T_c to the paramagnetic phase. We suppose that the lattice spins are Ising spins which interact with each other via a nearest-neighbor coupling. The distance-dependent interaction between an electron spin with lattice spins is limited inside a cut-off distance. Monte Carlo simulation has been shown to be very efficient to study the spin resistivity [1,2]. We study in particular the behavior of the spin resistivity at and near the magnetic phase transition where the effect of the magnetic ordering is strongest. In ferromagnetic crystals, the spin resistivity shows a sharp peak very similar to the magnetic susceptibility. This can be understood if one relates the spin resistivity to the spin-spin correlation as suggested in a number of theories. The dependence of the shape of the peak on physical parameters such as carrier concentration, magnetic field strength, relaxation time etc. is discussed. In antiferromagnets, the peak is not so pronounced and in some cases it is absent. Its direct relationship to the spin-spin correlation is not obvious. As for frustrated spin systems with strong first-order transition, the spin resistivity shows a discontinuity at the phase transition.

To show the efficiency of the simulation method, we compare our new results with recent experimental data performed on GdI2. We observe a very good agreement with experiments on the spin resistivity in the whole range of temperature.

References

[1] Y. Magnin, K. Akabli, H. T. Diep and I. Harada, Computational Materials Science, 49, S204-S209, 2010.

[2] Y. Magnin and H. T. Diep, Phys. Rev. B, 85, 184413, 2012.

[1] Laboratoire de Physique Théorique et Modélisation,
Université de Cergy-Pontoise, CNRS, UMR 8089
2, Avenue Adolphe Chauvin, 95302 Cergy-Pontoise Cedex, France.
diep@u-cergy.fr