ANOMALOUS AND SPIN HALL EFFECTS

V.K. Dugaev[1,2], P. Bruno[3]
[1]*Department of Mathematics and Applied Physics, Rzeszów University of Technology, 35-959 Rzeszów, Poland*
[2]*Department of Physics and CFIF, Instituto Superior Técnico, 1049-001 Lisbon, Portugal*
[3]*European Synchrotron Radiation Facility, BP 220, 38043 Grenoble, France*

We present an overview of existing theories of the anomalous Hall effect (AHE) and spin Hall effect (SHE), as well as the most recent results of experiments, which demonstrate a possibility of using these phenomena in spintronics applications. Different physical mechanisms proposed by theorists are briefly discussed. Among them there are side-jump, skew scattering, and a chiral mechanism related to the magnetic inhomogeneity. The main attention is paid to discussion of a most controversial "intrinsic" mechanism of the AHE and SHE, which has been commonly believed to dominate in magnetic semiconductors. In this context we discuss the critical role of disorder and scattering from impurities. This problem induced a lot of discussions among theorists, and a full consensus was not reached so far.

We also present an overview of theoretical ideas discovering the topological origin of the intrinsic AHE, which is related to nontrivial topology of electron energy bands and the Berry phase of electrons moving in the inverse space. It naturally leads to the quantization of Hall conductivity, i.e., to the possibility of quantum AHE.

It is known that the off-diagonal conductivity calculated by using the standard Kubo formalism in frame of the intrinsic model leads to result which seems to contradict formally to the Landau definition of Fermi liquid. The solution of this problem is found in a generalization of Landau's semiclassical approach of the Fermi liquid.