Anomalous Hall Effect and Spin Hall Effect for a Disordered Host: Breakdown of Traditional Paradigm

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Abstract. The description of magnetotransport has so far focused on how doping influences clean crystals. However, interest is turning also to substitutional alloys as hosts. Our aim is to investigate to what extent the approaches that proved to be useful for doped crystals can be applied to doped alloys. Calculations are performed for permalloy $Fe_{19}Ni_{81}$ doped with V, Co, Pt, and Au impurities, relying on the Kubo-Bastin equation implemented using the KKR-Green function method. The dependence of the anomalous Hall and spin Hall conductivities on the dopant concentration is nonmonotonic and strongly influenced by the temperature. The fact that the host is disordered and not crystalline has profound influence on how these conductivities depend on the dopant concentration. In particular, off-diagonal anomalous Hall and spin Hall conductivities are not proportional to diagonal charge conductivity for low dopant concentrations. Consequently, the dependence of the anomalous Hall effect and spin Hall effect on the dopant concentration cannot be ascribed unambigously to skew scattering, side-jump scattering, or intrinsic contributions in the same way as it can be done when investigating the effect of doping for a crystalline host, i.e., the standard scaling laws do not apply.