Accessing antiferromagnetism in metallic thin films through anomalous Hall effect

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Besides their fundamental role as pinning layers in spintronic devices, antiferromagnetic materials are gaining interest by themselves thanks to the ability to store information in a magnetic state that is unaffected by external fields [1]. The absence of a net magnetic moment, however, prevents any investigation of these materials through conventional magnetometric techniques. A possible route to probe antiferromagnetism electrically has been recently demonstrated in the Pt/Cr_2O_3 system by measuring the Anomalous Hall Effect arising from induced magnetization in Pt [2,3]. Here, using a similar approach, we present a combined study of resistivity, Hall and anomalous Hall in metallic antiferromagnetic thin films proving a general method to assess antiferromagnetism which relies only on electrical measurements.

At first, we validate the technique by determining the Neèl temperature T_N of IrMn thin films in a Ta(2 nm)/IrMn (4 nm)/Ta(2 nm)//SiO_2 heterostructure grown by magnetron sputtering. We first set a magnetic state by applying an out of plane field and cooling the sample below T_N. Depending on the field cooling (FC) direction, a different Anomalous Hall Resistance (AHR) is observed below T_N ~100K (Figure 1a). Underneath this temperature, the application of magnetic fields no longer affects the AHR signal, confirming its connection with the antiferromagnet state. We use the same approach to demonstrate antiferromagnetism also in epitaxial Chromium thin films grown on MgO. A small AHR dependent on field cooling can be reproducibly detected over the offset up to ~270 K for a Pt (3 nm)/Cr(50 nm)//MgO sample (Figure 1b). We will show that the occurrence of the Neèl transition in Cr is further corroborated by anomalies in both resistivity and normal Hall coefficient. The possible role of an interface-induced magnetization in Pt on the AHR, currently under investigation both theoretically and experimentally, will be discussed as well.

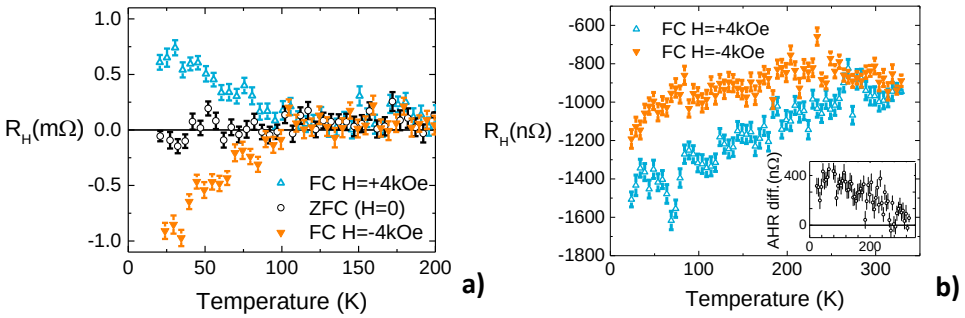

Figure 1. a) Comparison of anomalous Hall resistance upon different field cooling (FC) conditions in Ta/IrMn/Ta films. **b)** the same for a Pt/Cr sample, the inset shows the difference between the transversal resistance in the two cases.

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