Novel non-collinear spin texture for antiferromagnetic spintronics applications

Ferromagnetic materials (Fig. 1A) are widely used in spintronics applications. However, the stray field and relatively slow magnetic dynamics of ferromagnets (GHz) limit their application in the field of magnetic-based data storage technology. On the other hand, there is no stray field in antiferromagnets, and magnetic dynamics belong to the THz region, which is useful for high-density magnetic-based data storage and faster computation. Unlike ferromagnets, antiferromagnets usually do not show anomalous Hall effect or large magneto-resistance, thus, it was difficult to read the signal from it. After 2000, the experimental discovery of the spin Hall effect and related phenomena of spin Hall magnetoresistance shows a potential possibility for the detection of manipulated AFM state. Further, the discovery of electrical manipulation of collinear AFM in 2016 gave birth to the field 'Antiferromagnetic Spintronics'.

The collinear antiferromagnets are formed from two ferromagnetic spin sublattices where one spin makes an angle of 180° to the neighboring spin, and magnetic interaction is mostly determined by isotropic Heisenberg exchange interaction [figure 1B]. When a third spin is placed in between or close to those two collinear spins, magnetic frustration might happen, leading to chiral non-collinear or coplanar spin structures [figure 1C,D]. In this configuration, besides isotropic exchange interaction, anisotropic exchange interaction, which is known as Dzyaloshinskii-Moriya interaction, plays a crucial role in determining the ground state of the system, which could be antiferromagnet, ferromagnet, ferrimagnet, or helimagnet. The discovery of the anomalous Hall effect in non-collinear antiferromagnets and followed by the electrical manipulation of the same opens a new path in the antiferromagnetic spintronics field for magnetization-based data storage technology. A finite AHE is the best way to detect the two distinct magnetic states compared to spin Hall magnetoresistance. Till now only a few NC-antiferromagnets such as Mn_3X (X=Sn,Ge, Pt) show finite AHE and unconventional SHE which are restricted by certain crystal and magnetic symmetries. NC-AFMs show exotic magneto-transport properties similar to ferromagnets, but it does not depend on the net moment, rather, it is controlled by the intrinsic Berry phase.

Broadly, we are interested in the following areas: (i) magneto-transport properties of new non-collinear antiferromagnets, which will be fabricated using the ARC melting technique and sputtering. (ii) Magneto-transport properties of interfacial non-collinear spin texture formed from different types of magnetic heterostructure in the form of thin films.

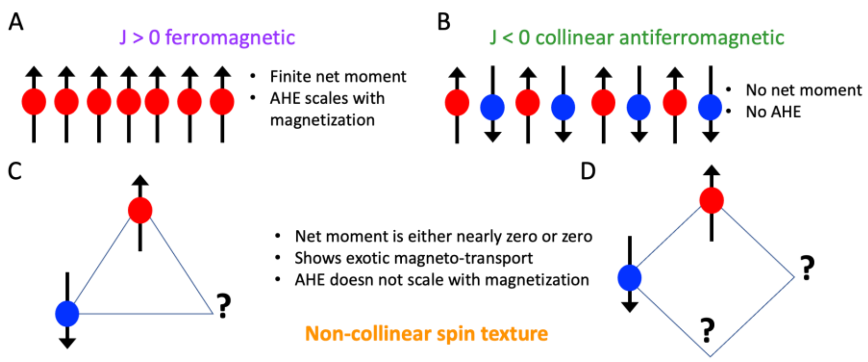

Figure 1: (A) Spin arrangement in a ferromagnet. (C) Illustration of spin arrangement in a collinear antiferromagnet. (B, D) Schematic representation of non-collinear spin textures which lead to antiferromagnetic ground state.