Exchange bias due to coupling between coexisting antiferromagnetic and spin-glass orders

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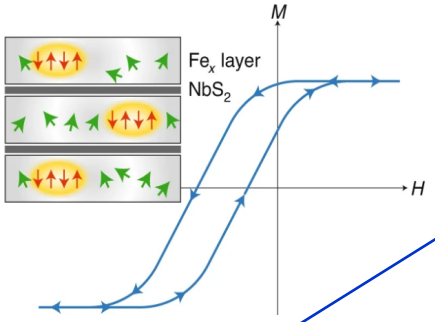
Ferromagnetism (FM) and anti-ferromagnetism (AFM) are stable magnetic states with an ordered arrangement of magnetic moments, typically determined by the crystal structure of the host material. By contrast, a spin-glass is a metastable magnetic state in a material in which the magnetic moments of the atoms are disordered in a manner that is a magnetic analog to the amorphous atomic structure of ordinary window glass.

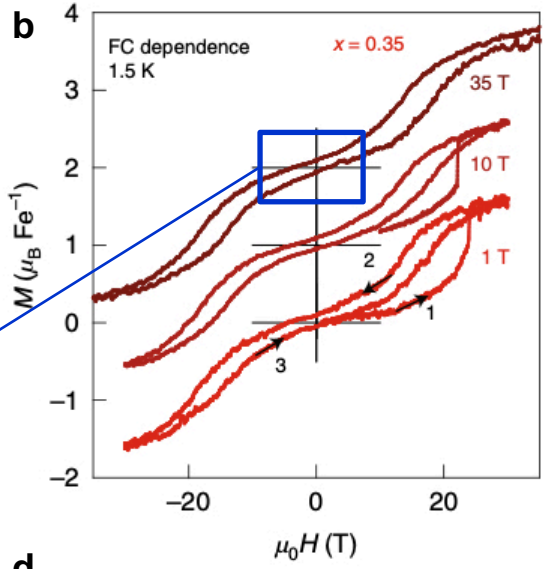
Fe_xNbS_2 is an unusual material in that it hosts both AFM and spin-glass states simultaneously, with the AFM state influencing the properties of the spin-glass state via the property of exchange bias. In previously studied thin film materials, this exchange bias results in the magnetization curves being offset by ~ 0.01T. *By contrast, in single crystal $Fe_{0.35}NbS_2$, researchers find that the exchange bias is ~ 1T, a factor of 100 greater*!

The demonstration of the role of disorder in the physics of exchange bias in a single crystal is a breakthrough. These results offer a compelling basis for more investigations on how bulk disorder impacts the exchange bias in devices beyond engineered thin film materials.

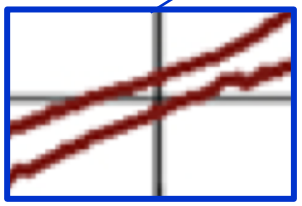
a Co-existence of Antiferromagnetism and Spin Glass orders in Fe_XNbS_2, including schematic of effect of exchange bias on magnetization curves



b

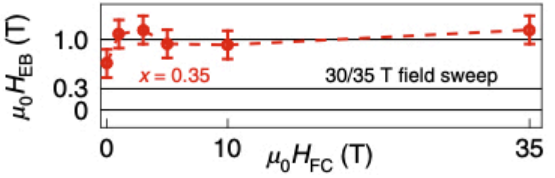


c



Enlarged image of 35T data from (b). Note asymmetry about the origin, due to the ~1T offset of magnetization curves in $Fe_{0.35}NbS_2$

d (b) and (d): Exchange Bias as a function of Magnetic Field Magnitude during Field Cooling



a: Schematic of the co-existence of antiferromagnetism and spin glass orders in Fe_XNbS_2
b: Out of plane magnetization curves for three different field-cooling conditions for $Fe_{0.35}NbS_2$.
c: Enlarged portion of the data from (b). **d:** Exchange bias magnitude as a function of the magnitude of field cooling, showing an exchange bias value of ~1T at all values of field cooling.

Facilities and instrumentation used: Cell 8, 35T

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