Lecture 27 - WiSe2022/2023

Monday, February 6, 2023 11:03 AM

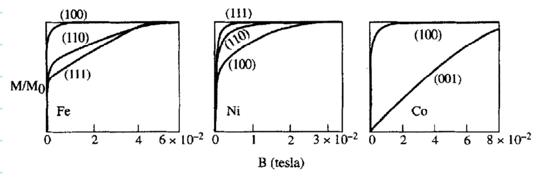
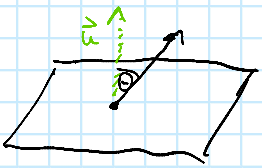
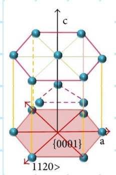


Fig. 6.22 Magnetization in Fe, Co and Ni for applied fields in different directions showing anisotropy. After Honda and Kaya 1926, Kaya 1928.

- Intrinsic property of the material
  ↳ given by the crystal structure
  ↳ and induced by the crystal
- 10 neV – 1 meV
- Phenomenological description
  magnetic free energy density $f_{Ani} = \frac{E_{Ani}}{V}$
  as a function of $\vec{m} = \frac{\vec{M}}{|\vec{M}|} = \begin{pmatrix} m_x \\ m_y \\ m_z \end{pmatrix} = \begin{pmatrix} \sin\theta\cos\varphi \\ \sin\theta\sin\varphi \\ 0 \end{pmatrix}$ } → probably wrong

Cobalt



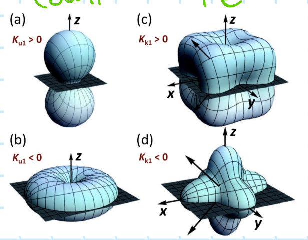


⟹ uniaxial anisotropy

in general

$$f_{uni} = K_{u1} |\vec{m}\cdot\vec{u}|^2 + K_{u2} \cdot |\vec{m}\cdot\vec{u}|^4 + \ldots \approx K_{u1} \cdot \cos(\theta)^2$$

Cobalt Fe



Fe: cubic, easy axis is along <100>

Co: hexagonal lattice ~ uniaxial lattice

- Reason for magnetocrystalline anisotropy: spin-orbit-interaction

Crystal lattice (Coulomb) ⟹ Non-sperical e- distribution ⟹ modifies spin-orbit interaction ⟹ MCA

Shape Anisotropy

Shape matters:

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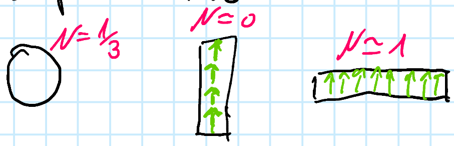

Magnetostatic energy:

$$E_m = -\frac{\mu_0}{2}\int \vec{M}\cdot\vec{H}_N \, dV = \frac{\mu_0}{2}\int \vec{M}\cdot N\cdot\vec{M}\, dV$$

using $\vec{H}_N = -N\cdot\vec{M}$ (demagnetization field)

N: Demagnetization factor (usually tensor)

E_{shape}: the energy required to get from the most preferred to the most unpreferred direction