Amorphous ferrimagnet $RFeCo$ – phase transitions

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1 Introduction

The task is to reconstruct spin distribution (θ_d) as a function of magnetic field (H) and rare earth concentration (x) by given hamiltonian E. In other words, find a value θ_d at which the energy E is minimal.

2 Hamiltonian

We are given hamiltonian:

$$H = -x\boldsymbol{M}_f\boldsymbol{H}_{eff} - (1-x)\boldsymbol{M}_d\boldsymbol{H} - xK_f\left(\frac{\boldsymbol{M}_f}{M_f}\boldsymbol{Z}\right)^2 - (1-x)K_d\left(\frac{\boldsymbol{M}_d\boldsymbol{H}}{M_dH}\right)^2 \tag{1}$$

where:
$\boldsymbol{H}$ - external field
$\boldsymbol{M}_f$, $\boldsymbol{M}_d$ - magnetization
$\boldsymbol{H}_{eff} = \boldsymbol{H} - \lambda\boldsymbol{M}_d$
$\boldsymbol{Z}$ - anisotropy vector,

In zero approximation $\boldsymbol{Z}||\boldsymbol{H}$. By introducing θ_d such that $\boldsymbol{M}_d\boldsymbol{H} = M_dH\cos\theta_d$ we obtain:

$$H = -xM_fH_{eff} - (1-x)M_dH\cos\theta_d - xK_f\left(\frac{\boldsymbol{M}_f}{M_f}\boldsymbol{Z}\right)^2 - (1-x)K_d\cos^2\theta_d \tag{2}$$

Fro physics we know that $\boldsymbol{M}_f \sim \chi_f\boldsymbol{H}_{eff}$, so:

$$\frac{\boldsymbol{M}_f}{M_f}\boldsymbol{Z} = \frac{\boldsymbol{H}_{eff}}{H_{eff}}\boldsymbol{Z} = \frac{\boldsymbol{H} - \lambda\boldsymbol{M}_d}{H_{eff}}\boldsymbol{Z} = \frac{H - \lambda M_d\cos\theta_d}{H_{eff}} \tag{3}$$

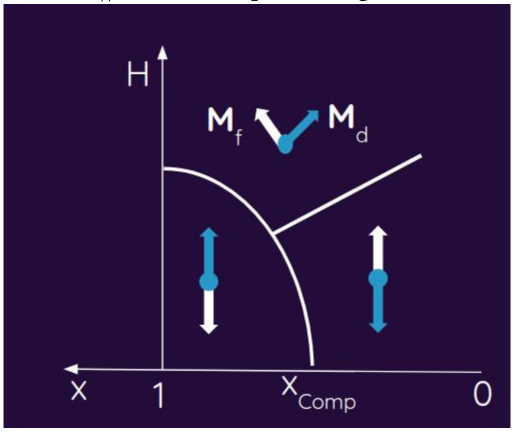
Defining the last expression as $\cos\theta_f$ we get:

$$H = -xM_fH_{eff} - (1-x)M_dH\cos\theta_d - xK_f\cos^2\theta_f - (1-x)K_d\cos^2\theta_d \tag{4}$$

Constants:
$M_f = 10\mu_B$,
$M_d = 5\mu_B$,
$\lambda -$ interaction integral,
$\lambda Md = 500kOe$
$K_f = 0.5K = 0.51.410^{-16}erg$
$K_{d,f} \ll \lambda M_dM_f$

3 Expected results

When $\boldsymbol{Z}||\boldsymbol{H}$ we are expected to get smth like that:



Than we should let $\boldsymbol{Z} \sim N(\mu, \sigma^2)$

4 Current results

Github repository contains all current code and results. The most important jupyter notebook is *ferrimagnet/phase_diagram.ipynb*