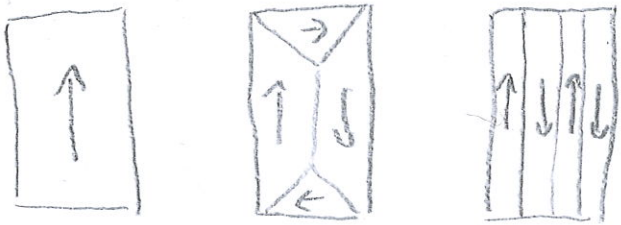
2 Hysteresis

Review

Which 3 types of domain states do we know?



SD PSD (vortex) MD

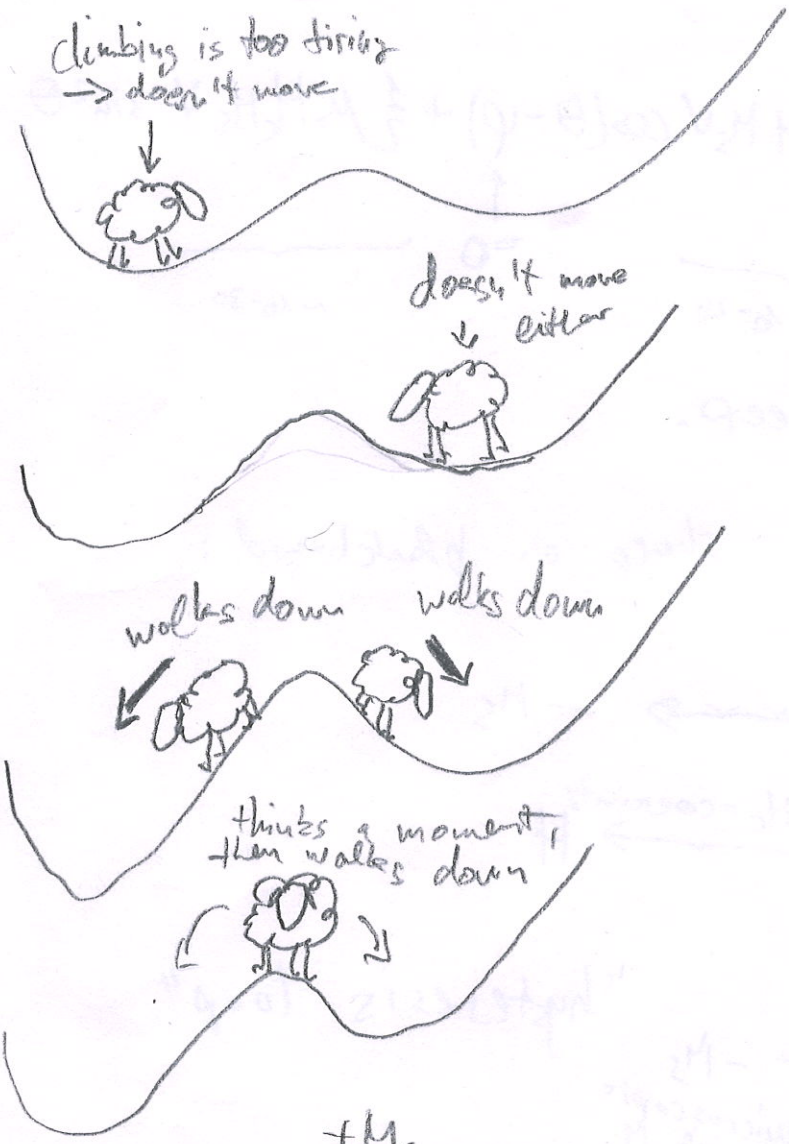
What are the energies of SD & MD grains?

$$E_{SD} = -\mu_0 H M_S V \cos(\theta - \varphi) + \frac{1}{2}\mu_0 H_K M_S V \sin^2\theta$$

$$E_{MD} = \underbrace{-2\mu_0 H M_S A x}_{\text{magnetostatic (external field) } E_H} + \underbrace{2\mu_0 H_K M_S A^2 x^2}_{\text{demagnetizing (internal field) } E_d} + \underbrace{\gamma_w A(n-1)}_{\text{Domain wall } E_W}$$

Hysteresis: "memory effect" → the "state" of a system depends on its past.

Sheep in the valley



$-M_S$ $+M_S$

sheep = magnetic moment

valley = energy

Sheep always walk down into the next valley
the mag. moment always moves into the closest
energy minimum

Plot the energy of a SD grain in desmos.com, with slider H.

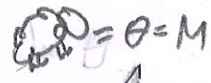
$$E_{SD} = -\mu_0 H M_s V \cos(\theta - \varphi) + \frac{1}{2}\mu_0 H_k M_s V \sin^2\theta$$

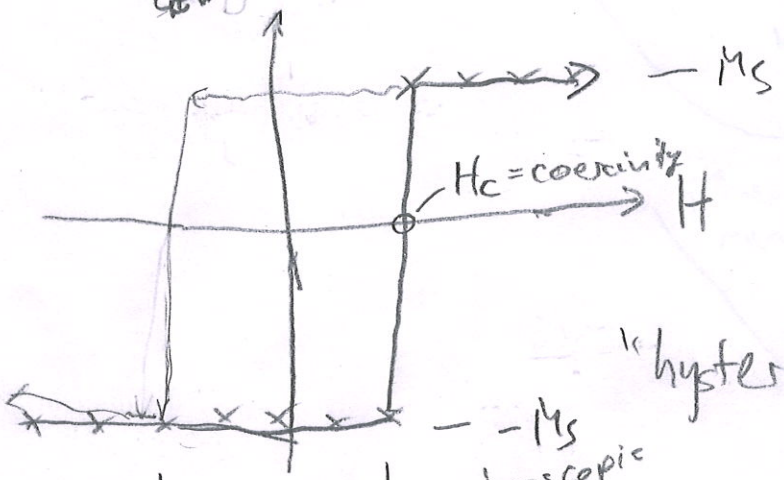
$\varphi = 0$

$\sim 10^{-25}$ $\sim 10^{-30}$

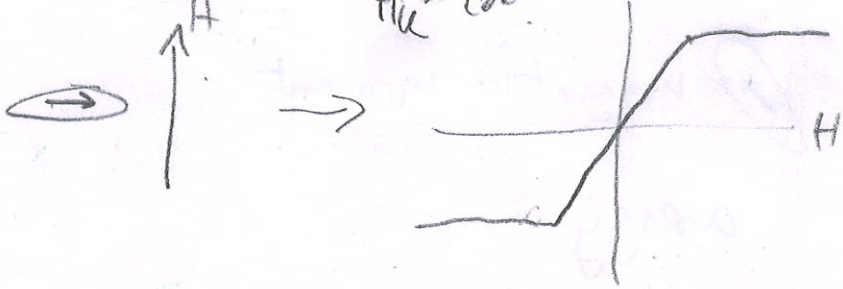
Volunteer plays sheep.

Plot movement of sheep on blackboard:

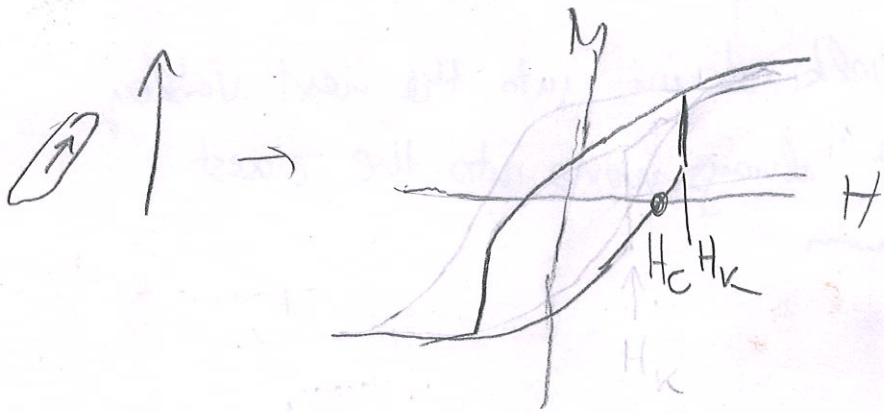




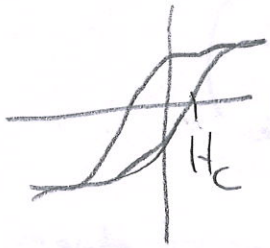
"hysteresis loop"



⇒ no hysteresis

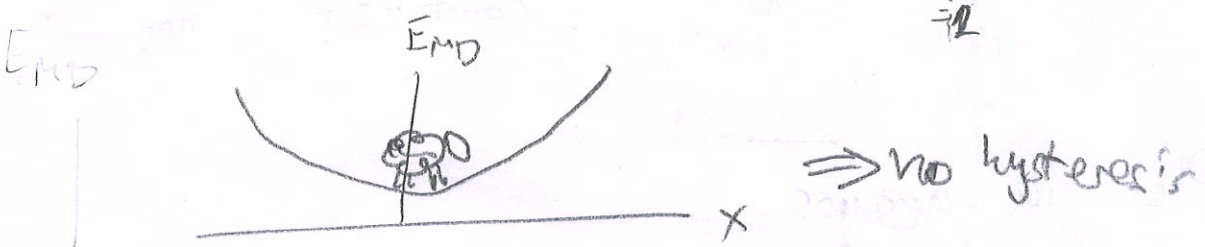


Sample with many randomly aligned particles:



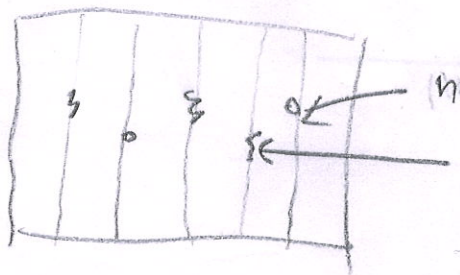
Plot the energy of an MD grain:

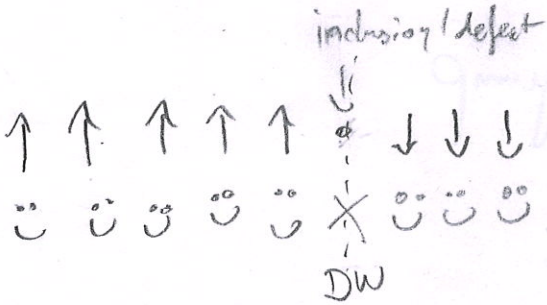
$$E_{MD} = -2\mu_0 A M_S H x + 2\mu_0 N A^2 M_S^2 x^2 + \gamma_w A (\underbrace{\mu - 1}_{=1})$$

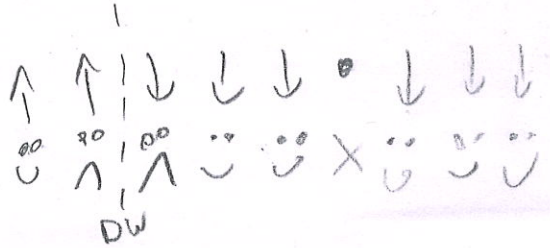


$\Rightarrow$ no hysteresis

But: Barkhausen jumps







$\Rightarrow$ DW prefer ~~to~~ be at impurities / defects!