

# Dynamic hysteresis in magnetic thin films

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## Studying dynamic hysteresis with two-dimensional MuMax2-simulations

- Films with flux-closed domain structure
- 5 x 5  $\mu\text{m}$  squares, thickness 50 nm
- Both pure and disordered films
  - Magnitude of disorder  $\sim 2\%$

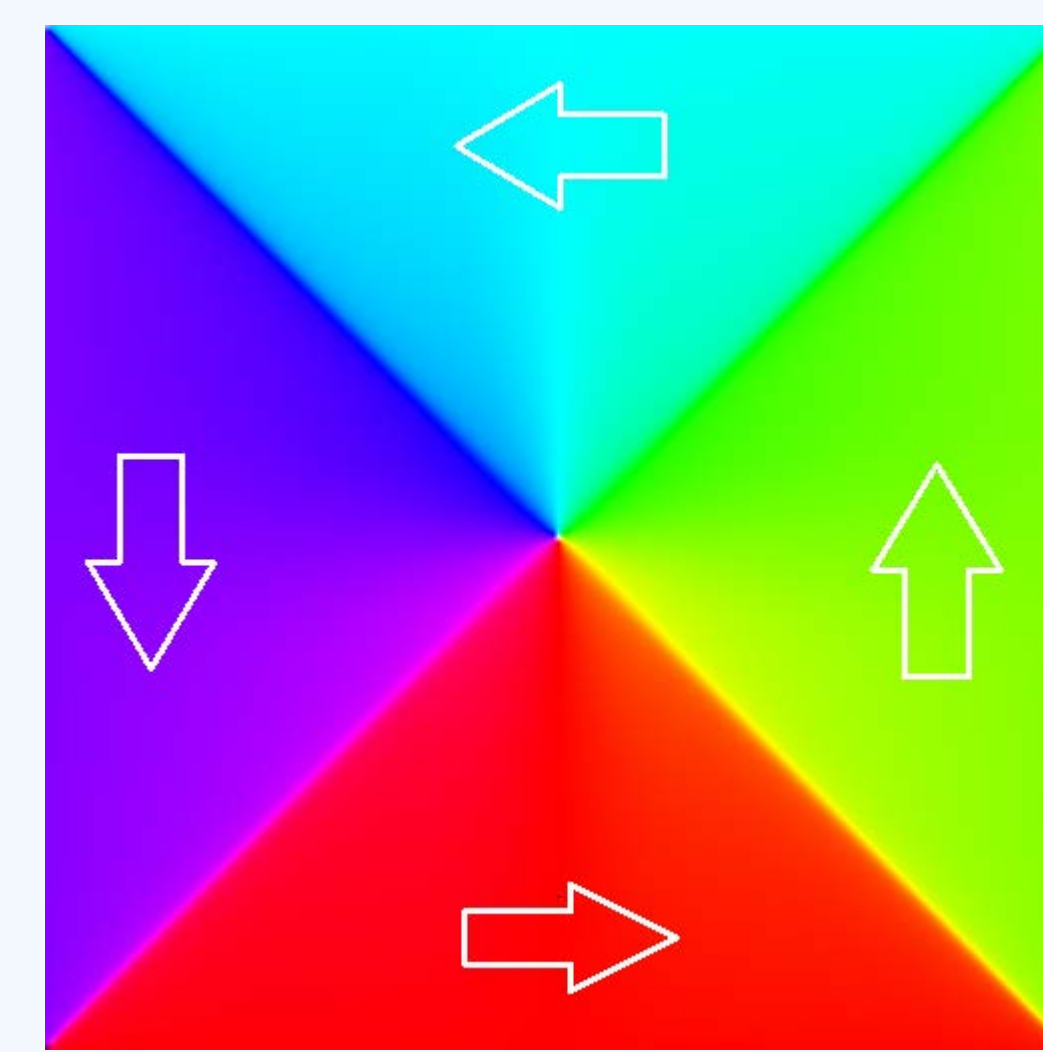


Figure 1: Initial magnetization state.

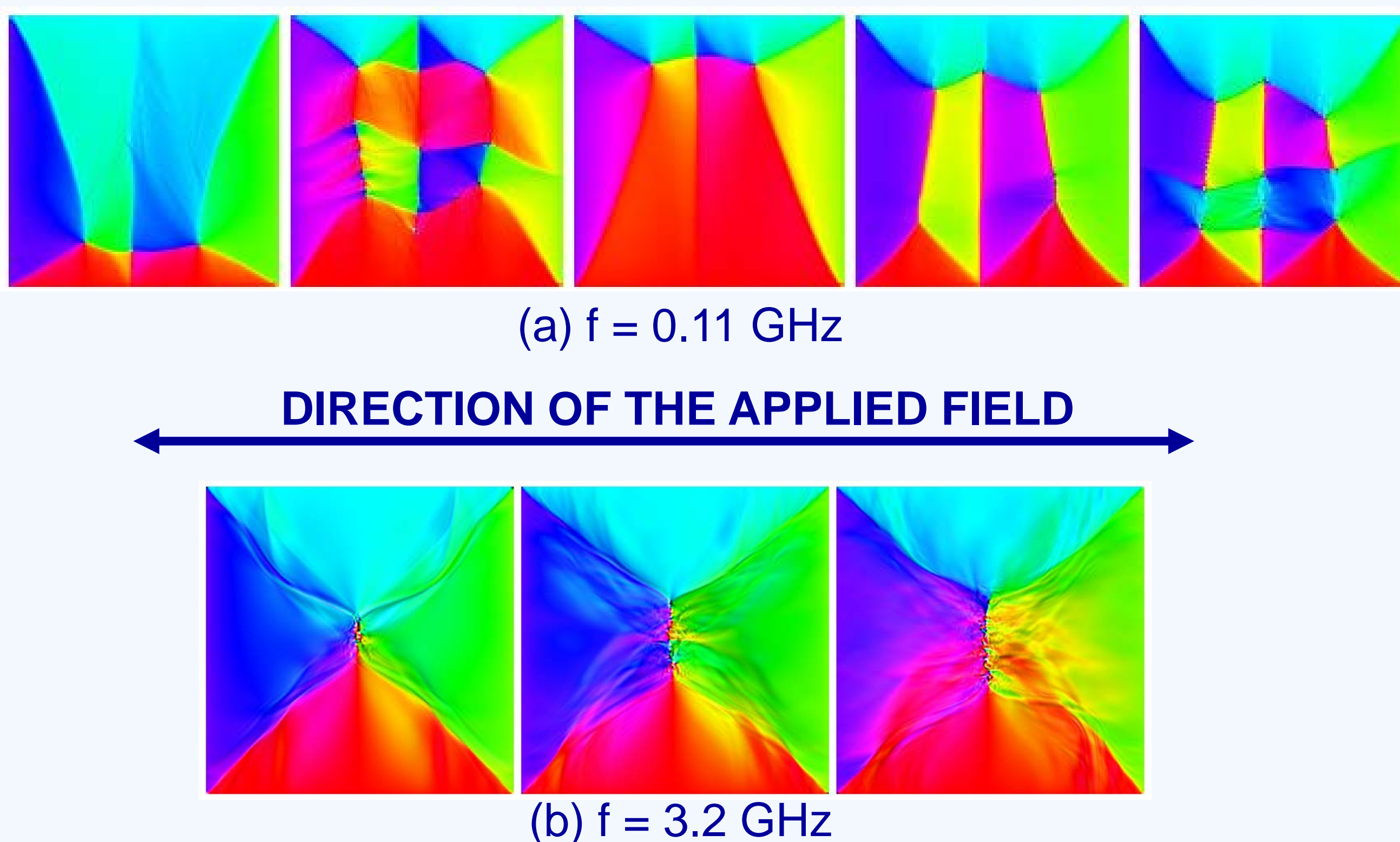


Figure 2: Examples of DW motion with amplitude  $H_0 = 9\text{ mT}$ .

## Mechanisms of domain wall (DW) motion

- Apply sinusoidal magnetic field  
 $H = H_0 \sin(2\pi f \cdot t)$ 
  - Amplitudes  $H_0 = 1\text{ mT}, 3\text{ mT}, 9\text{ mT}$
  - Frequencies  $f = 0.01 \dots 6.5\text{ GHz}$
- Motion mechanisms differed at low and high frequency ranges and with different amplitudes
- Characteristic timescales of the dynamic mechanisms are comparable to certain frequencies **➡ RESONANCE**

## Hysteresis loops

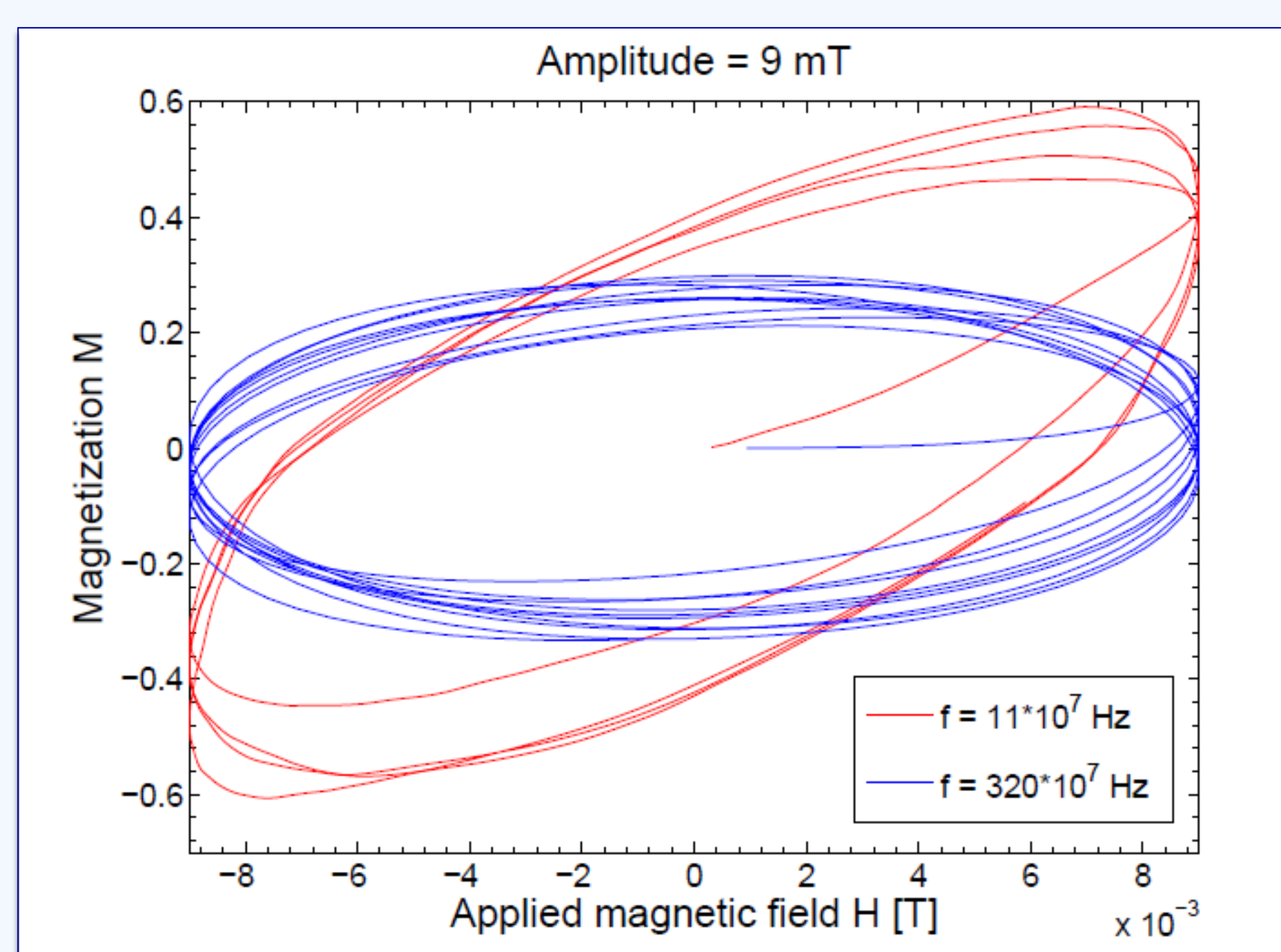


Figure 3: Hysteresis loops corresponding to the resonance peaks with amplitude 9 mT.

- Loop shape is affected by different amplitudes  $H_0$  and frequencies  $f$
- Area  $A$  corresponds to energy loss
- Resonance frequencies give the maximum loop areas  $A$

## Results & conclusions

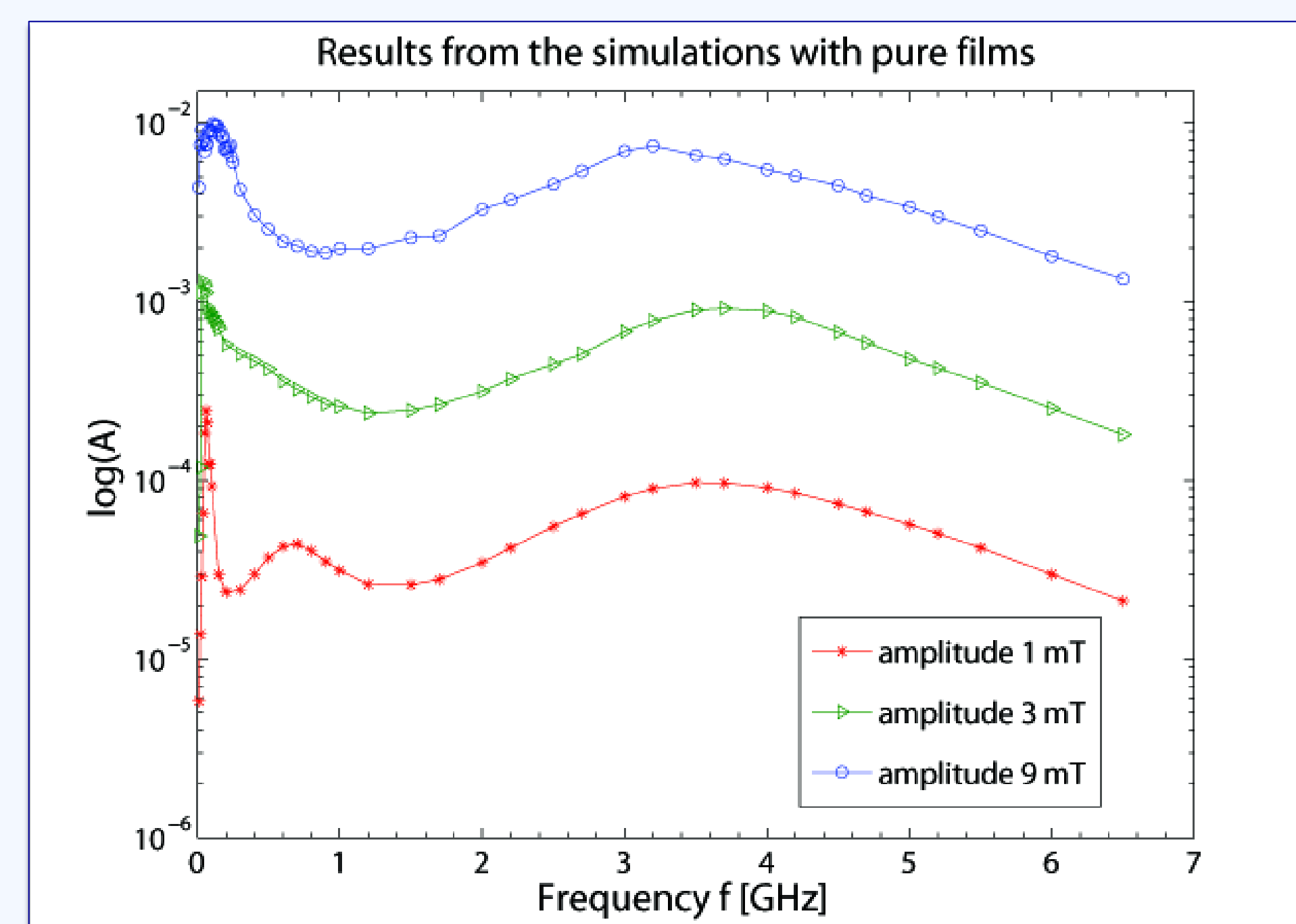


Figure 4: Loop areas as a function of frequency without disorder.

- Resonance peaks in  $(f, A)$ -plots
- Approximate relation  $A \sim H_0^2$
- Disorder had only little influence
  - Greatest differences with the smallest amplitude 1 mT