Motivation

A magnetic domain wall (DW) is a spatially localized variation of magnetization inside a magnetic structure. Depending on the lateral dimensions and material properties, two types of domain walls appear in thin films, which are topologically not equivalent [1]: Vortex and transverse walls.

Domain walls behave like particles with a finite (inert) mass. The inert mass is being caused by a contraction of the DW during motion [2].

Domain walls will interact with magnetic fields and can be manipulated with electrical currents due to several different mechanisms (momentum transfer/spin transfer / Oersted field/hydrodynamic force) [3].

The shape of a magnetic element will form a potential landscape for DWs due to the change in energy of a wall at different positions (e.g. structure width).

Nanoconstrictions will cause a potential $V$ which might be attractive (transverse wall) or repulsive (vortex wall).

Transverse walls are attracted by a constriction while vortex-walls are repelled by the constriction.

In the case of spatial symmetry around the minimum the potential $V$ can be calculated from the cycle duration $T$ for different energies $E$ as for the classical anharmonic oscillator:

$$x(V) = \frac{1}{2m} \sqrt{\frac{T(E)}{4\pi}} \sqrt{V + B}$$

Transverse walls are attracted by a constriction while vortex-walls are repelled by the constriction.

Imaging of DW in Constrictions

**PEEM (for results see MA 20.117), SEMPA, electron holography**

Operating principle of electron holography:
- An electron beam is split into a signal and a reference beam.
- The signal beam passes through the sample.
- The biprism causes the beams to interfere on a screen.

After considerable computation the field distribution can be obtained.

The images below show the two different domain wall types.

- **Transverse wall**
- **Vortex wall**

Electron holographic image series showing domain walls in constrictions of different sizes.

- The smaller the constriction width $x$ the smaller the domain wall.
- The insert shows the direction of the magnetic field.

References


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