Modelling of magneto-thermoelectric response from a domain Wall

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Motivation

The motivation of this work is the understanding of thermoelectric microscopy, which is a powerful tool to make images of spins textures. It is related with magneto-thermoelectric effects, which are non-equilibrium phenomena related to spin, charge and energy transport.

In this work, we have found that the experimental observations can be well understood by considering the Anomalous Nernst effect (ANE) in combination with Spin Seebeck effect (SSE).

Modelling

Numerical integration of LLB equation [1]:

\[
\frac{dm}{dt} = -\gamma [m \times H_{\text{eff}}] + \frac{\gamma_0}{m_I} (m \cdot H_{\text{eff}}) m - \frac{\gamma_0}{m_I} (m \times [m \times H_{\text{eff}}])
\]

Thermal diffusion model as a function of probe position:

\[-k \nabla^2 T = Q \quad \text{Ultra-thin layer} \Rightarrow \nabla_x T = 0\]

Magneto-thermoelectric effects:

\[
\begin{align*}
E_x &= -\left(\nabla V_x - \frac{1}{2} \frac{m_x}{m_I} \nabla^2 \mu_x \right)T \\
E_y &= -\left(\nabla V_y - \frac{1}{2} \frac{m_y}{m_I} \nabla^2 \mu_y \right)T \\
E_z &= -\left(\nabla V_z - \frac{1}{2} \frac{m_z}{m_I} \nabla^2 \mu_z \right)T
\end{align*}
\]

Magnetic configurations

Experiment & Simulation

Conclusions

- Scanning thermal microscopy is a powerful tool for mapping magnetic structures via thermo-magnetic effects: anomalous Nernst and spin-Seebeck.
- The ANE response is the same for Bloch and Neel domain walls.
- The Neel and Bloch domain walls can be distinguished via the asymmetry of the spin-Seebeck effect. (Fitted from experiment)
- Using the LLB micromagnetics and temperature distribution we modelled the induced voltage in FeCoB trapeze with PMA and geometrical notch in agreement with experiment.
- Domain wall is deformed and can be depinned from the notch and attracted by the heat spot.

Bibliography