Detection of magnetization fluctuations using the anomalous Hall effect

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The investigation of magnetization fluctuations reveals more information about defects and magnetization dynamics than for example a simple magneto-transport measurement [1]. We here exploit the direct proportionality between the anomalous Hall effect and the magnetization to deduce information about magnetic fluctuations from noise measurements of the Hall voltage.
As a starting point, we measure the noise power spectral density in magnetic heterostructures in dependence of a magnetic field perpendicular to the sample. Depending on the magnetic saturation of our ferromagnetic thin films, the measured noise power spectral densities show a different magnitude and shape. The measured noise power quantitatively agrees with the fluctuation-dissipation theorem which states that the noise power scales linearly with the susceptibility $\partial V_{\mathrm{H}}/\partial B$, where V_{H} is the Hall voltage and B the external magnetic field [2]. To be able to measure magnetization noise above the noise floor of the measurement device we choose Ti/Pt/Co/Ti-thin films that exhibit perpendicular magnetic anisotropy and therefore have a large susceptibility $\partial V_{\mathrm{H}}/\partial B$.
To enhance the sensitivity of the measurement we use cross-correlation measurements of the transversal voltage. By analyzing the temporal evolution of the transversal voltage, we show that the noise power spectral density has a $1/f^2$ -dependence if Barkhausen-like jumps are visible in the Hall voltage trace $V_{\mathrm{H}}(B)$, and a $1/f$ -dependence otherwise. Moreover, it can be observed that the noise power spectral density is greater the more Barkhausen-like jumps occur in the temporal evolution of the transversal voltage and the greater their amplitude.
Our results provide the basis for further investigations of magnetization fluctuations using the anomalous Hall effect. By variation of certain parameters, such as temperature or sample volume, we intend to gain further insights into the physical mechanisms behind magnetization noise in the future.

References:

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