A10

Magnetic Noise of Magnetoelectric Sensors

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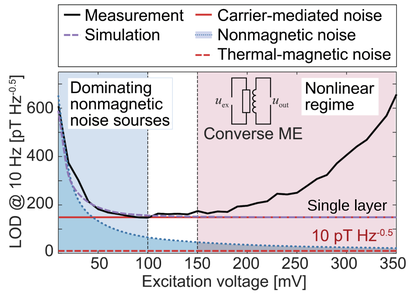
biomagnetic sensing SFB 1261

Motivation and Objectives

Magnetic noise + magnetoelastic nonlinearities [A10-8] – major limitations for sensor performance

- Sensor performance limited by magnetic noise
- Broad spectrum of magnetic noise types
- Magnetic noise on multiple scales

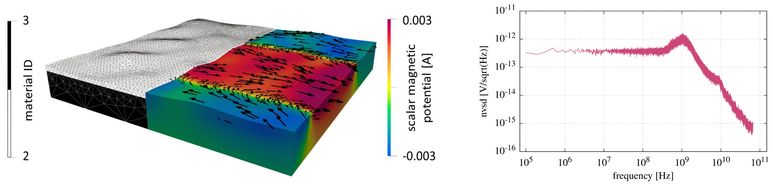


Main objectives

- Identify and quantify magnetic noise types in CRC sensors
- Provide input for sensor improvement
- Transfer noise knowledge from micro- to sensor-scale

Results of the Second Funding Period

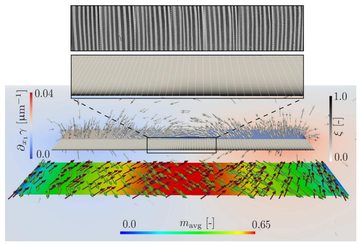
Barkhausen Noise Spectra Simulation [A10-10]



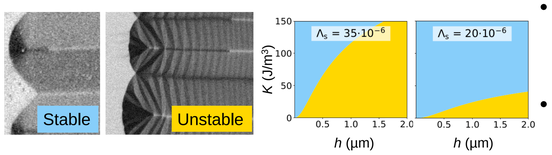
- Novel solution scheme for study of interaction of domain walls and structural defects
- Noise computation scheme based on ensemble averaging

Thin-film Stripe Shaped Magnetic Domain Continuum Theory [A10-7]

- Efficient meso-simulations compared to micromagnetics
- More microstructural details compared to macro models
- Basis for upscaling of noise



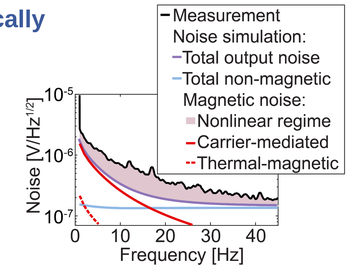
Stability Analysis of Undulating Magnetization States



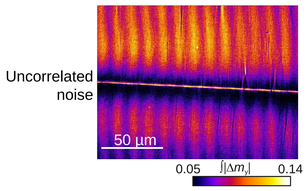
- Analysis of emergence of undulating magnetization
- Stability criterion as guideline for layer design

Magnetic Noise in ΔE-effect and Electrically Modulated Sensors [A10-8]

- Correlation between magneto-elastic nonlinearity and increased noise
- Carrier-mediated noise determines lowest LOD of multi-domain samples
- Theoretical minimum of LOD defined by the thermal-magnetic noise
- Similar noise behavior observed for other sensor types



Magnetic Noise and Domain Walls in SAW Sensors [A10-3, A10-4]



- Correlation between losses, noise, and magnetic domain behavior
- Domain walls modify magneto-mechanical response
- Source of noise in SAW operation magnetic

Work Plan for Third Funding Period

WP1 Establishing Preconditions

- Mesoscopic continuum theory and exchange-bias model
- Reconfiguration of magnetooptical imaging setup

WP2 Magnetostrictive Material Properties

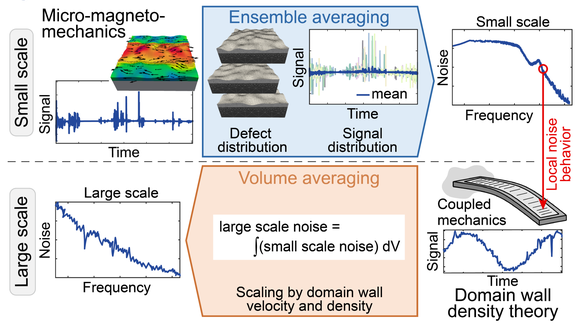
- Thermal noise based on χ'/χ'' phase diagrams (fluctuation-dissipation)
- Influence of heterogenous effective magnetic properties

WP3 Exchange Bias – Antiferromagnetic Layer Effects

- Influence of antiferromagnetic layer on noise
- Attribution of noise to ferromagnetic and antiferromagnetic layers

WP4 Magnetic Multilayer Stacks

- Exchange bias, anisotropy, magneto-statics for single-domain state
- Magnetically soft layers with good sensitivity

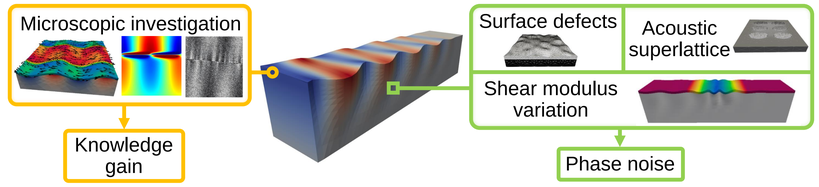


WP5 Noise – Magnetic Domains and Nonlinearities

- Upscale noise using mesoscopic continuum theory
- Pointwise incorporate microscale noise results from the current period

WP 6 Sensor Investigations

- Application and validation of noise computation scheme from WP5
- Phase noise simulation of SAW sensor in the frequency domain
- Small-scale investigation to understand vibrational domain wall modes



	Group McCord	2024		2025			2026				2027				2028	
	Group Wulfinghoff	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2
WP1	Establishing preconditions																
WP2	Magnetostrictive material properties																
WP3	Exchange bias effects																
WP4	Magnetic multilayer effects																
WP5	Noise, magnetic domains, nonlinearities																
WP6	Sensor investigations																

Collaborations

A1: Layer preparation/characterization, model validation
A2: Simulation of the micro and macro composite system
A4: ΔE sensor preparation/characterization, noise modeling and validation
A6: Structural parameter investigation
A7: Converse ME sensor preparation/characterization, model validation
A8: Exchange of modeling results from different scales
A9: SAW sensor preparation/characterization, noise model validation
B1: Compact noise model development
B10: Include sensor models and findings in forward model
B11: Include sensor models and findings in forward model
Z1: General sensor preparation
Z2: Joint sensor characterization (ME properties and noise spectra)

Participation in focus groups

F1: Modeling
F2: Sensor Concepts
F3: Comparison of Sensor Concepts
F5: Concepts based on Delta-E Effect

Funds Requested

1 Doctoral researcher, 1 Postdoctoral researcher, direct costs: 13.0 k€

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[A10-3] Müller, C., Durdaut, P., Holländer, R. B., Kittmann, A., Schell, V., Meyners, D.; Höft, M.; Quandt, E.; **McCord, J.**; Adv. Electron. Mater., 8(6) (2022), 2200033. **– A9, A10, B1, Z1**
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