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Visualisation of mobile magnetic domain walls with neutron grating interferometry

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The visualisation of dynamic processes with neutron grating interferometry (nGI) has not yet been studied to an extend where application could be useful. This is mostly due to the typically long exposure time of nGI experiments that are in the range of 20 minutes to several hours per dataset. We present an experimental, as well as data analysis, procedure that allows us to image repetitive processes using nGI while still being able to tune neutron statistics to an appropriate level by adjusting exposure time.
Neutron grating interferometry is a neutron imaging technique that builds on the wave nature of the neutron by introducing three gratings into the beam that either absorb parts of the beam or introduce well defined phase shifts. As a consequence of these gratings interference patterns are generated. Changes in the shape of the interference pattern can be analysed with regard to attenuation (TI), phase shift (DPCI) and small angle scattering (DFI) within the sample.
In order to retrieve TI, DPCI and DFI the interference pattern is scanned using a phase stepping approach with an analyser grating. The more phase steps are recorded the better the quality of the images. Each phase step is an image itself with the typical rule of more exposure time, better statistics. The type of data acquisition makes nGI a rather slow technique that is not typically suited for the investigation of dynamic processes. However, advanced detector technology in combination with appropriate hardware triggering makes it possible to investigate repetitive processes using nGI.
The investigation of magnetic domains in electrical sheets has been an important subject in which neutron grating interferometry contributed to the development in recent years [1,2]. These studies investigate the magnetic domains walls as static and drew conclusions from the extrapolated behaviour that the static data suggested about the mobile nature of the domains. In our work, we present the next experimental step in the analysis of mobile magnetic domains by presenting a setup in combination with appropriate data analysis to visualise the movement of the domain walls directly up to 50 Hz.

[1] Betz, B., et al. “Frequency-Induced Bulk Magnetic Domain-Wall Freezing Visualized by Neutron Dark-Field Imaging.” Physical Review Applied 6.2 (2016): 024024.

[2] Rauscher, P., et al. “The influence of laser scribing on magnetic domain formation in grain oriented electrical steel visualized by directional neutron dark-field imaging.” Scientific Reports 6 (2016): 38307.

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