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Magnetization process in large grain ferromagnets studied by polarized neutron imaging

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Polarized neutron imaging (PNI) uses Larmor spin precession to spatially resolve bulk magnetic properties [1]. In recent years, it has been advanced with applications like visualizing magnetic domains [2] or vector-fields [3].
Grain oriented silicon steels, which are used as magnetic core material, have grains and magnetic domains in the mm to cm range and a preferential magnetization axis. Here, we present PNI measurements of the the magnetization process in a thin sheet in applied fields up to 4.5mT.
In the remanent state, part of the sample shows stripe magnetic domains, which are aligned with the rolling direction and appear to be uniform through the thickness of the sample. A different part is highly disordered, but reorganized into similar stripe domains above 3.0mT. In addition, the crystal grain structure plays a visible role.
The experiment required perpendicular magnetic fields for retaining the polarization and achieving the sample magnetization, However, since field variations outside the sample affect the neutron spin, we have used finite element and ray tracing simulations in the experimental planning and data analysis, to account for additional spin rotations.
Our results provide a direct observation of the magnetic domains during magnetization, and highlight the capability of PNI to investigate macroscopic inhomogeneities of magnetic materials.
[1]: M Strobl et al., Journal of Phys. D: Applied Physics 52 (2019)
[2]: K. Hiroi et al., Physica B: Condensed Matter 551 (2018)
[3]: A. Hilger et al., Nature Communications, 9.1 (2018)

Author: BACKS, Alex (Lund University , ESS)

Co-authors: ORLOV, Dmytro (Lund University); STROBL, Markus (PSI); BUSI, Matteo; SEBOLD, Simon (MLZ); Dr LEE, Wai Tung (Hal) (European Spallation Source)

Presenter: BACKS, Alex (Lund University , ESS)

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