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Magnetic Small-Angle Neutron Scattering. A Probe for Mesoscale Magnetism Analysis. By Andreas Michels. Oxford University Press, 2021. Pp. 384. Price (hardback) GBP 80.00. ISBN 9780198855170.

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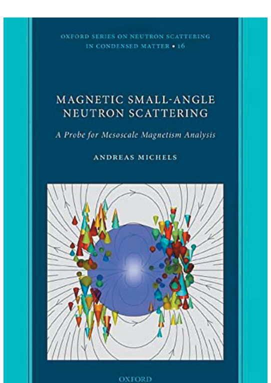
With its unique sensitivity to magnetic inhomogeneities on mesoscopic length scales, magnetic small-angle neutron scattering (SANS) has emerged in recent years as one of the most important methods for magnetic microstructure determination in condensed-matter physics and materials science. However, as it is based on the nanoscale variation of both orientation and magnitude of the magnetization vector, the well established theories for nuclear SANS do not go far enough in many cases to describe the magnetic SANS cross section. This is particularly relevant for the diffuse magnetic SANS resulting from the spin misalignment present in inhomogeneous and nonuniformly magnetized materials such as nanostructured bulk ferromagnets, magnetic vortices, nanoparticles and ferrofluids, magnetic steels, spin glasses, and amorphous magnets.

This book is therefore a perfect fit to fill the gap in the existing literature and provide a comprehensive overview on the magnetic SANS technique. It uniquely discusses the full theoretical background of polarized SANS and gives extensive examples of diffuse magnetic SANS experiments. The great strength of this book is in its additional focus on the application of numerical micromagnetic simulations to experimental scattering data. This approach has lately seen a massive development and is a very promising means to tackle the resolution of three-dimensional mesoscale spin structures in the near future.

The book is organized in seven chapters. The first chapter provides the reader with an introduction to the basic expressions of neutron scattering cross sections and the elastic magnetic SANS cross section. It emphasizes the origins of magnetic SANS and its differences from conventional particle scattering.

Chapters 2 and 3 provide the basic concepts of SANS and micromagnetism. Both chapters give a concise overview of the most important aspects needed to follow the discussion of magnetic SANS. Chapter 2, *Basics of SANS*, starts with general aspects of experimental setups and instrumental resolution. It discusses the influence of inelastic SANS contributions such as phonon and magnon scattering on the energy-integrated SANS signal, highlighting the left–right asymmetry method using polarized neutrons to study helical spin dynamics. After summarizing the basics of nonmagnetic SANS, including the relation of scattering cross sections and correlation functions, the chapter proceeds to the specifics of magnetic SANS. Based on the magnetic scattering vector, the unpolarized and polarized magnetic SANS cross sections are provided for the two most commonly used experimental setups. A discussion of the derived magnetic SANS cross sections at magnetic saturation establishes the connection to the particle–matrix concept. Chapter 3, *Basics of Static Micromagnetism*, introduces the main micromagnetic energy contributions and the static equations of micromagnetics. For the approach-to-saturation regime, the micromagnetic equations can be linearized and the transverse Fourier components of the magnetization, related to the spin misalignment, are derived. These are directly connected to the magnetic SANS cross section and provide a measure for the autocorrelation function of the magnetization, defining the characteristic length scale of the system. The magnetic SANS is hence intimately linked to fundamental micromagnetic parameters (such as exchange, anisotropy, magnetostatics) and microstructure (*e.g.* the particle form factor).



Chapters 4 and 5 are dedicated to the combination of SANS and micromagnetism and the application of magnetic SANS to the mesoscale magnetism in different classes of materials. In Chapter 4, *Magnetic SANS of Bulk Ferromagnets*, the analytical micromagnetic description is applied to obtain the polarized and unpolarized SANS cross sections. These simplifications allow the author to discuss the basic features of magnetic SANS on bulk magnetic materials, including the effects of magnetocrystalline anisotropy, magnetodipolar stray fields, ferromagnetic exchange and Dzyaloshinskii–Moriya interaction on the angular scattering anisotropies, the magnetic Guinier law, the asymptotic power law behaviour, and the polarization and magnetic field dependence of the magnetic SANS. Examples are given for soft and hard magnetic nanocomposites, nanocrystalline rare-earth magnets with random paramagnetic susceptibility, and dislocations in cold-worked metals. Chapter 5, *Magnetic SANS of Nanoparticles and Complex Systems*, is dedicated to the application of magnetic SANS to nonuniformly magnetized magnetic nanoparticles, frequently described utilizing the conventional particle–matrix-based model. The difference from the bulk materials discussed in previous chapters is the 3D spatial confinement, which may aggravate crossing length scale scenarios, and the emergence of complex magnetization states. First attempts to solve the encountered micromagnetic boundary-value problem are introduced in detail for vortices in flat cylinders, which resemble in the ground state a meron. The chapter closes with an overview of the magnetic SANS applied to ferrofluids, magnetic steels, spin glasses and amorphous magnets as well as a diverse collection of further applications.

Chapter 6, *Real-Space Analysis*, is dedicated to the analysis of spin-misalignment correlations in real space, an approach that can facilitate a more intuitive understanding of the underlying magnetic structures by their characteristic length scales. The correlation function and correlation length of the spin misalignment are introduced and discussed in the context of micromagnetic theory, providing a general and model-free tool to analyse magnetic SANS. The chapter closes with selected experimental results on nanocrystalline Nd–Fe–B-based permanent magnets and nanocrystalline elemental soft and hard magnets.

Chapter 7, *Micromagnetic Simulations*, sketches the progress made using full-scale micromagnetic simulations for the understanding of the fundamentals of magnetic SANS. Numerical techniques allow one to consider full 3D complex magnetic structures and to derive the corresponding scattering cross section without high-field approximations that tolerate only small deviations from collinear magnetic moments. The chapter discusses the flexibility that exists in modelling sample microstructures, the simulation methodology and how the different energy contributions are implemented, and highlights simulation results on nanocomposite bulk magnets and magnetic nanoparticles.

In my opinion, this is an excellent book, providing an in-depth account of the combination of magnetic SANS with micromagnetic theory and a comprehensive overview of the progress made in relevant topics of mesoscale magnetism. The book will serve as an introduction for those getting started with using SANS as a characterization technique for magnetic materials, with ample references to the existing literature to facilitate further reading. The experienced user will find both a complete account of what to expect from a polarized SANS experiment and a source of inspiration to unlock the full potential of experimental data in combination with up-to-date numerical simulations to advance our understanding of nanoscale magnets.