# Magnetic Small-Angle Neutron Scattering
## From nanoscale magnetism to long-range magnetic structures

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Small-angle scattering (SAS) is one of the most important techniques for mesoscopic structure determination (length scale 30 Å -3000 Å) being utilized in a wide range of scientific disciplines such as materials science, physics, chemistry, and biology. Sensitive to magnetism, small-angle *neutron* scattering (SANS) also provides a unique magnetic contrast. As such, SANS ideally complements more direct imaging techniques, *e.g.* scanning and transmission electron microscopy, Kerr microscopy, atomic force microscopy, or scanning tunneling microscopy.

The application of SANS to study magnetism and magnetic materials covers a wide range of topics from fundamental questions in condensed matter physics to applied problems in materials science [1]. More specifically, the problems and materials classes which can be studied using magnetic SANS range from nanomagnetic systems such as soft magnetic Fe-based nanocomposites, hard magnetic Nd-Fe-B-based permanent magnets, magnetic steels, ferrofluids, nanoparticles, and complex magnetic oxides to more fundamental open issues in condensed matter physics such as skyrmion crystals, noncollinear magnetic structures in noncentrosymmetric compounds, magnetic or electronic phase separation, and vortex lattices in type-II superconductors.

The topics of magnetic SANS as listed above can be tentatively grouped into two larger themes: Skyrmionic textures, the variety of incommensurate helical and spiral long range magnetically ordered structures, complex magnetic systems with nanoscale magnetic inhomogeneity such as magnetically/electronically phase separated complex oxide/metal alloys, and finally vortex lattices of type–II superconductors share a nanoscale magnetic structure, emerging from the microscopic electronic properties of macroscopically homogeneous samples. Accordingly, these systems are typically described using microscopic models with their origin in condensed matter physics and strongly correlated electron systems.

This is contrasted by the magnetism of nanoscale materials, such as *e.g.* magnetic nanoparticles, ferrofluids, nanotextured materials or nanocomposites. The nanoscale magnetic properties of these materials are imprinted by their intrinsic nanostructure, which is large enough for the atomistic structure to be ignored, yet small enough to consider magnetic structures like domain walls or vortices. Accordingly, a continuum micromagnetic approach is typically used to successfully describe the magnetic properties and the related magnetic SANS of these samples.

We provide an introduction into the theoretical and instrumental concepts of magnetic SANS, its extensions and applications on selected examples.

[1] Reviews of Modern Physics 91, 015004, (2019)