Magnetic small-angle neutron scattering – from nanoscale magnetism to long-range magnetic structures. Scope of the proposed special issue of *Journal of Applied Crystallography*

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This special issue will focus on the technique of magnetic small-angle neutron scattering (SANS), which is one of the most important methods for magnetic microstructure determination in condensed-matter physics and materials science. Magnetic SANS provides access to bulk properties and yields, quite uniquely, information on the mesoscopic length scale (roughly 1-1000 nm). This is an important size regime where many macroscopic materials properties are realized. Currently, the magnetic SANS community can be roughly subdivided into two large, nearly disconnected groups.

The research of the first group is anchored in the domain of condensed-matter physics with a focus on fundamental questions related, *e.g.*, to the formation and stability of skyrmion crystals and topological spin structures, to complex long-range-ordered spin structures, or to vortex lattices in superconductors. In this field, the studied materials are mostly structurally homogenous on the nanoscale, in many cases single crystals are investigated, and the nanoscale magnetism in these systems emerges due to correlations and instabilities in the electronic structure or due to competing interactions and frustration. The investigated magnetic structures are commonly driven by temperature, applied magnetic or electric fields, or other external parameters, and the magnetization distribution in these materials forms a long-range-ordered periodic lattice, which is then best studied using a SANS instrument in diffraction mode.

The second group of scientists employs the magnetic SANS method in the classical diffuse sense, *i.e.* the scattering along the forward direction due to a non-periodic arrangement of magnetic structures. The studied materials, *e.g.* permanent magnets, magnetic steels, nanoparticles and ferrofluids, or complex alloys, exhibit an intrinsic nanoscale structural inhomogeneity, most of them are polycrystalline, and this structural inhomogeneity couples to the magnetization distribution. Microstructural defects, *e.g.* vacancies in nanoparticles, dislocations in deformed metals, interfaces in nanocrystalline materials, or pores in steels, play a decisive role, since large spin inhomogeneities are created in the vicinity of the respective defect core, and this spin disorder can be very well studied with the magnetic SANS technique. Here, a description and modeling of the related mesoscale magnetism and concomitant magnetic scattering in terms of a micromagnetic continuum description has proven to be very suitable and also promising for future studies.

Despite SANS providing unique and valuable information for magnetic materials, and increasingly to systems of technological importance, it has traditionally been rather poorly promoted and supported within the small-angle scattering community. *Journal of Applied Crystallography* is the traditional home for small-angle scattering applications and we believe that an opportunity exists to raise the profile of the field.

The central aims of this special issue are therefore

(i) to highlight the versatility of science cases which can be addressed with the magnetic SANS technique,

(ii) to emphasize the complementarity of techniques applied by the above-mentioned two disconnected research communities,

(iii) to address future challenges related to magnetic SANS theory, neutron instrumentation, sample environment and neutron data analysis.

The idea for this special issue was born from the occasion of a recent Wilhelm and Else Heraeus workshop (https://www.we-heraeus-stiftung.de/veranstaltungen/seminare/2021/magnetic-small-angle-neutron-scattering-from-nanoscale-magnetism-to-long-range-magnetic-structures/), where we have successfully brought these two groups of researchers closer together by providing a stage for intra- and interdisciplinary scientific exchange. It was realized that there is the necessity to summarize the state of the art in the field of magnetic SANS, which has undergone enormous scientific development in both theory and experiment in recent years. We believe that *Journal of Applied Crystallography* is the most suitable platform for such an endeavour, since this journal reaches out to the whole SAS community and is a well-established reference for some of the most important milestone papers in SAS.