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The impact of sample geometry on vortex structures arising in superconductors and chiral magnets - A neutron imaging approach –

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Magnetic flux lines in type-II superconductors as well as skyrmions, are topologically stabilized objects exhibiting strong particle-like behavior. In both cases, the interplay of (i) vortex-vortex interactions, (ii) interactions with the underlying electronic structure and (iii) interactions with impurities results in complex phase diagrams and metastable states. Since the vortices tend to form regular patterns on the sub-µm range, small-angle neutron scattering (SANS) is frequently employed in order to study their nucleation, stability and crystallography. During data evaluation, the sample shape is commonly considered by scaling the applied field according to the sample's demagnetization factor. Since demagnetizing fields are inhomogeneous for non-ellipsoidal cross-section and e.g. corners can act as preferred nucleation sites of vortices, the morphology of the vortex phase may deviates throughout the sample. We demonstrate on the skyrmion lattice in MnSi [1] and the flux line lattice in Niobium [2] that neglecting geometric effects can promote drastic misinterpretation of neutron scattering data. Using complementary neutron radiographic techniques like grating interferometry or diffractive imaging, which provide spatially resolved information about the distribution and morphology of vortex structures, intrinsic effects can be clearly distinguished from geometry induced behavior.

[1] T. Reimann et al., Phys. Rev. B 97, 020406(R)
[2] T. Reimann et al., Nat. Commun. 6:8813

Primary author: Dr REIMANN, Tommy (Helmholtz Zentrum Dresden Rossendorf)

Presenter: Dr REIMANN, Tommy (Helmholtz Zentrum Dresden Rossendorf)

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