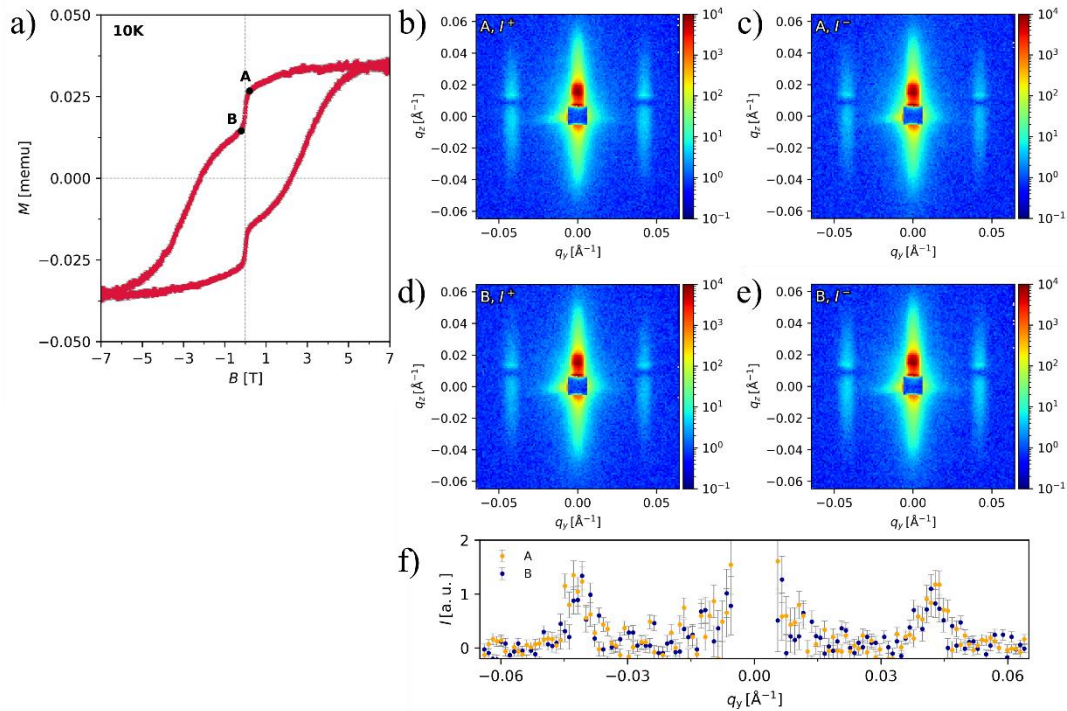


## Experimental Report: Dipolar correlations in square arrays of magnetic nanoparticles

The aim of this study was to use polarized GISANS to investigate the interparticle coupling in cobalt ferrite nanocube arrays. Our nanoparticle arrays reveal a strong secondary magnetization reversal (Fig. 1, a) that might be associated with a transition between superferromagnetic (SFM) and superantiferromagnetic coupling (SAFM) between the nanoparticles.

Polarized GISANS measurements were carried out at low temperatures (10 K) in two different field conditions, named 'A' and 'B' in the isothermal magnetization curve (Fig. 1, a), i. e. just before and after the secondary magnetization reversal. The magnetic field was generated using a cryomagnet with the field direction parallel to the neutron beam with a wavelength of  $\lambda = 6 \text{ \AA}$ , a collimation of 2.8 m, and a sample to detector distance of 5 m.

Exemplary GISANS detector images are presented in Fig. 1, b-e. The Yoneda lines for all channels at "A" and "B" field condition exhibit a lateral Bragg reflection around  $q_y = 0.0416 \text{ \AA}^{-1}$ , corresponding to a square lattice constant of 15.10 nm. There is considerable magnetic contrast in this reflection between the two polarization channels for both measurements, indicating SFM order within the lattice (Fig. 1, f). However, there is no significant difference between the magnetic contrast in A and B field conditions and no indication of a SAFM Bragg reflection in any field condition.



**Fig.1:** a) Field-dependent magnetization measurement at  $T = 10 \text{ K}$ . Two positions at which GISANS was measured are marked with "A" and "B". Polarized GISANS detector images at  $T = 10 \text{ K}$  (ZFC) for position "A" at b)  $I^+$  and c) at  $I^-$  and at position "B" at d)  $I^+$  and e) at  $I^-$ . f) Difference of the Yoneda data for the  $I^+$  and  $I^-$  channel at positions "A" and "B".

Investigation of a second sample in different field geometry, with the applied field oriented horizontally, perpendicular to the neutron beam and the vertically oriented substrate, led to very similar results.