ESRF	**Experiment title:** Correlation in arrays of superparamagnetic nanodots	**Experiment number**: HC-667
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Report:

The aim of the proposed experiment was to study the interaction in arrays of superparamagnetic nanodots [1]. A detailed study of thermally activated single nanodot switching has been performed based on anomalous Hall-Effect measurements [2], while the picture of ensemble-averaged correlation information of such systems is so far incomplete [3,4].To determine the time constants of the thermally activated spontaneous magnetization reversal the X-ray Photon Correlation Spectroscopy (XPCS) techniques was employed. XPCS studies the dynamics of equilibrium and non-equilibrium processes occurring in condensed matter systems by correlating speckled small-angle X-ray scattering patterns [5].To confirm the stability of the experimental setup, which is a prerequisite for XPCS measurements, we investigated a static Co/Pt multilayer sample at room temperature. Due to the disordered maze domain structure of this sample we expected to get a time invariant series of speckle patterns (see Fig. 1b)), e.g. the intensity autocorrelation function $g_2(\Delta t)$ should be constant for all time delays Δt. Fig. 1a) shows the average number of photons per second over the elapsed measurement time. One can clearly see that we have a loss of nearly ~60% in recorded intensity. This leads to a drop of the autocorrelation function g_2 over the time delay(Fig.

1c)). The beam intensities are far below the threshold where heating effects are taking place. Hence, the changes in the speckle structure of the CCD pattern are solely due to beam intensity instability. These beam fluctuations superimpose with the intrinsic magnetic nanodot dynamics and hence make XPCS measurements with the goal to extract the time constant of the nanodot switching behavior futile.

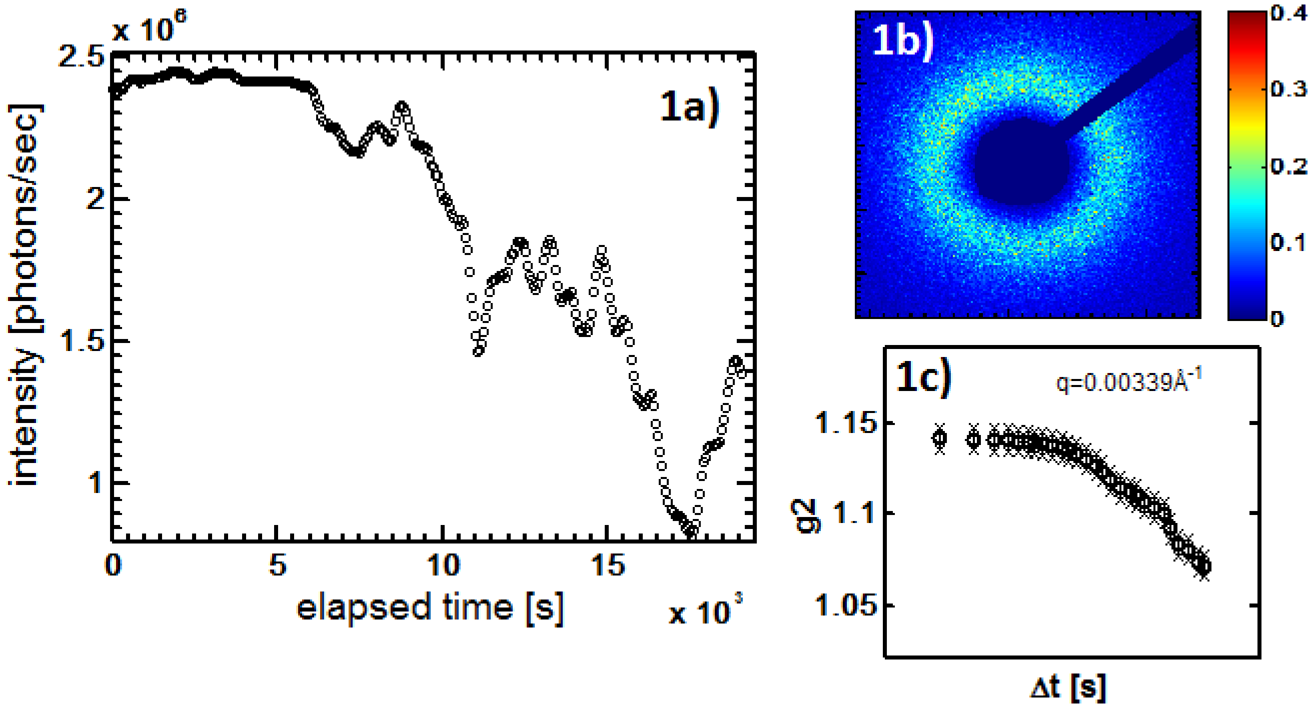

Figure 1: a) Averaged number of photons per second vs elapsed measurement time, extracted from each speckle pattern. b) Representative speckle pattern of a laterally structured Co/Pt multilayer sample. c) Intensity autocorrelation function g_2 (Δt) vs time delay Δt.

Only toward the very end of the beamtime it turned out that the beam stability had improved, which could be due to less extreme temperature transients outside. Thereupon, we measured the magnetization reversal of a Co/Pt nanodot sample consisting of an irregular array of 20 nm diameter nanodots with an average distance of 70 nm, as deduced from the structure factor (Fig. 2c)). After cooling the sample to 150 K, which corresponds to the magnetically blocked state, in-plane magnetic fields of different strength were applied to trigger the reversal dynamics and to adjust different switching times. Fig. 2a) shows a speckle pattern of a nanodot sample with a preferred structural orientation, which leads to a slightly asymmetric scattering ring. The beam intensity fluctuations are around ~10% (see Fig. 2b)), now allowing for meaningful XPCS measurements. The intensity autocorrelation function exhibits a constant value, i.e. no field driven switching dynamics was observable.

Due to lack of remaining beamtime, measurements of different nanodot samples with various inter-particle distances at varied temperatures (up to 300 K) could no more be carried out.

Future beamtimes at the ID32 would be highly welcome to deduce the missing parameters which are needed to improve the understanding of the switching behavior of magnetic nanodot ensembles.

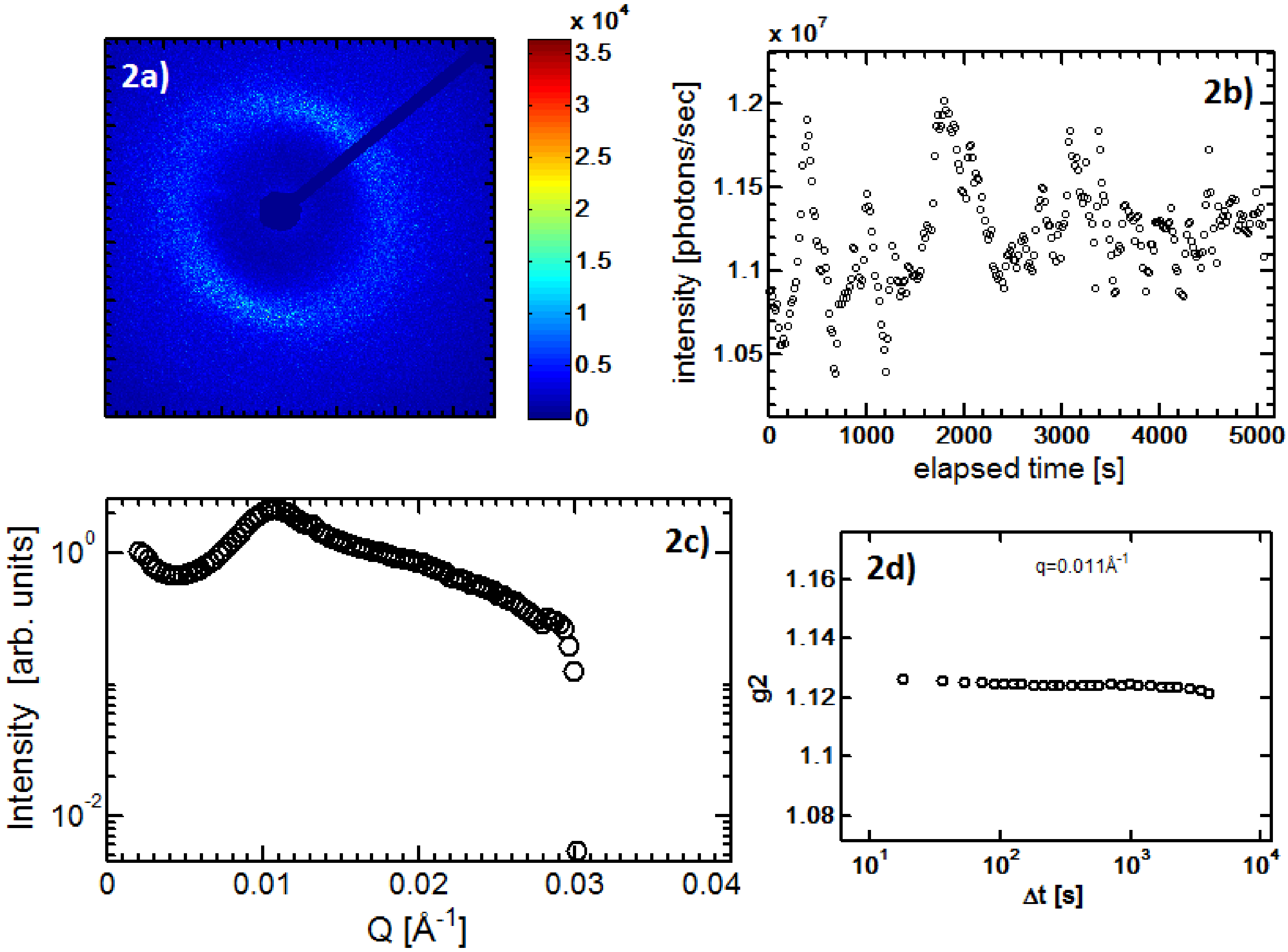

Figure 2: a) Speckle pattern of a Co/Pt nanodot sample at T=150 K at an in-plane magnetic field of 90 mT. b) Averaged number of photons per second vs elapsed measurement time. c) Structure factor with maximum located at q_{max} = 0.108 nm^{-1} (corresponds to an average particle distance of 63 nm). d) Intensity autocorrelation function.

References

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