Experimental report

05/04/2024

Proposal: 9-10-1772 **Council:** 4/2023

Title: Magnetic field induced long-range ordering in magnetic nanoparticle 2D-superlattices: A POL-GISANS studyat the free liquid interface

Research area: Physics

This proposal is a new proposal

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Samples: Iron oxide Fe3O4 Nanoparticles(10nm size) in toluene.

Instrument	Requested days	Allocated days	From	To
SUPERADAM	6	4	30/11/2023	04/12/2023

Abstract:

The understanding of self-assembly of nanoparticles into large area, defect free 2D-superlattices is of big interest for fundamental science as well as for creating a plethora of functional devices with enhanced collective properties. The understanding and tuning of interparticle interaction parameters, such as, surfactant shell interaction, particle size dependant effects and magnetic interaction between magnetic particles are of key to understanding the process and creating new devices. We are interested in the self-assembly of magnetic nanoparticles at the free liquid surface and the potential long-range ordering effects of an applied magnetic field. We aim to investigate this with Polarized Grazing Incidence Small Angle Scattering(POL-GISANS) in situ in a Langmuir trough environment at SuperAdam, taking full use of the incoming beam by a switch of sample orientation from vertical to horizontal. We propose to study 2D-superlattice formation with and without an imposed magnetic field at different surface pressures at a free liquid surface. In total, we ask for 6 days of beam time at SuperAdam

Experimental Report 9-10-1772

The experiments of this proposal consisted of testing a custom langmuir trough environment for GISANS studies at the air/liquid interface at the SuperAdam instrument. GISANS data of magnetic core/shell nanoparticles of size 100 nm was measured with and without an applied weak magnetic field of approximately 25 Gauss at the air/liquid interface of a Langmuir trough environment, see figure 1. Both polarized and non-polarized data was acquired. Measurements were done at applied surface pressures of 45 mN/m and 20mN/m.

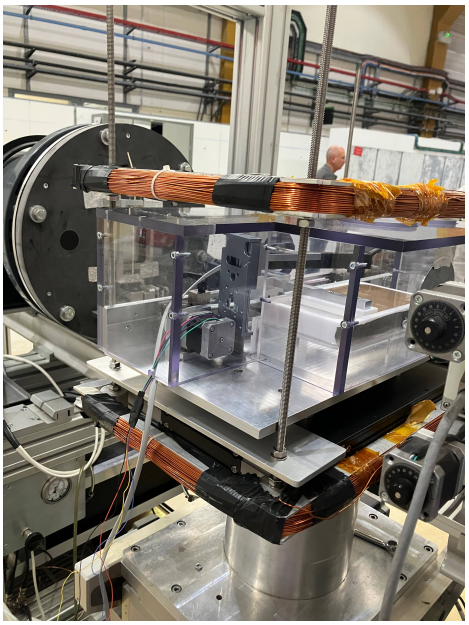

Figure 1: custom trough set up

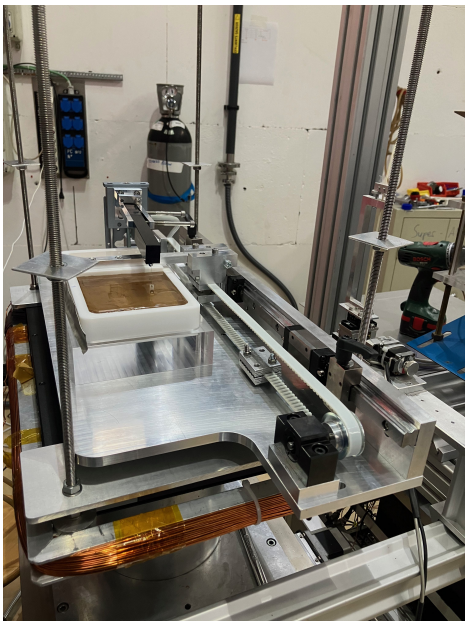

Figure 2: Custom trough set up

After correction of detector efficiency, 2D detector images were integrated vertically. From the polarized data, weak peaks corresponding to lateral structure of the nanoparticle film can be seen. Shown in fig 3 For the unpolarized data, shown in fig 5, broad featureless scattering was observed. Likely because of a broadening of the direct beam. This could be due to a change of the morphology of the nanoparticle film over time, since the film was not replaced between experiments.

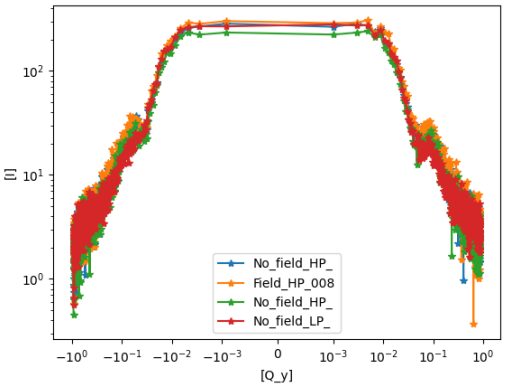

Figure 3: Polarized data (corrected for detector efficiency)

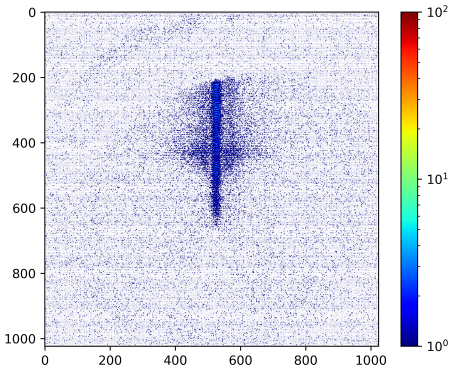

Figure 4: Raw data 2D detector map

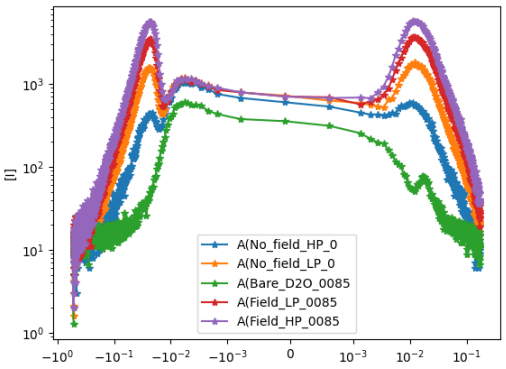

Figure 5: Non-polarized data (Not corrected for detector efficiency

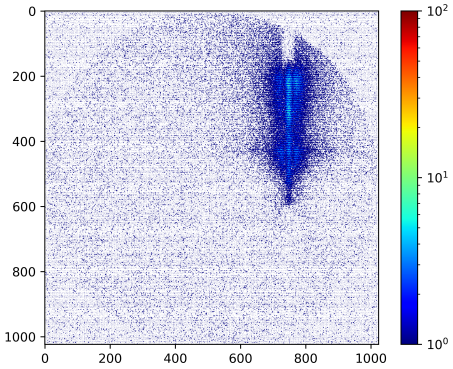

Figure 6: Raw data 2D detector map

Based on these results a new langmuir trough for in situ measurements has been designed. The trough will consist of a pure monocrystalline Si-block, see fig 7, to ensure as low background as possible. This will enhance the signal-to-background ratio. A follow up experiment that utilizes this trough is planned for spring 2024.

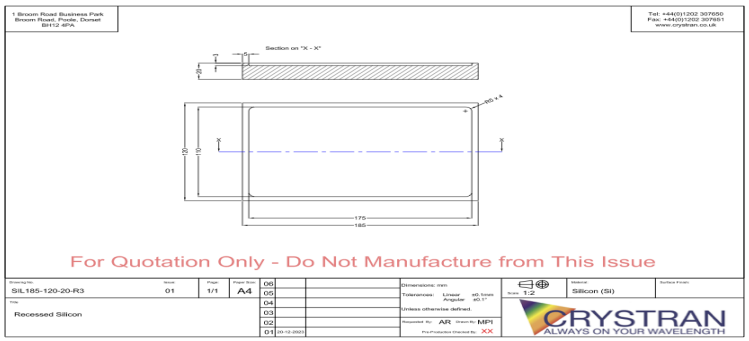

Figure 7: Design for monocrystalline Si trough