Report of the first year

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Scientific Degree : Candidate of science - condensed matter Physics (SPBU) 21 June2021

Titled (**Magnetic properties of iron nanowire arrays: the impact of geometrical parameters**).

Current position : Researcher Postdoc Fellowship [20 Nov. 2023 – Present]

Group : FLNP – YuMO [Small Angle Neutron Scattering]

Field of work

- Magnetic nanowire materials
- nanowires and nanomaterials
- FORC analysis
- Small Angle Scattering

Publications:

- El-Din, IMA Tag; Hassan, SSA; El-Din, MSM Nour; Almekawy, AH. (2015) Treatment of total reaction cross section for proton and antiproton scattering from 3He.Journal of Nuclear Science and Applications,,48,4,219-236,2015,
- Elmekawy A. H. A., Iashina E. G., Dubitskiy I. S., et al. (2020) Magnetic properties and FORC analysis of iron nanowire arrays.Materials Today Communications.
- doi: https://doi.org/10.1016/j.mtcomm.2020.101609
- Elmekawy Dubitskiy I. S., Elmekawy A. H. A., et al. (2021) Effect of Interactions and Non-uniform Magnetic States on the Magnetization Reversal of Iron Nanowire Arrays.Journal of Superconductivity and Novel Magnetism. doi: https://doi.org/10.1007/s10948-020-05711-y
- Elmekawy AHA Elmekawy, E Iashina, I Dubitskiy, et al. (2021) Magnetic properties of ordered arrays of iron nanowires: The impact of the length.Journal of Magnetism and Magnetic Materials. doi: https://doi.org/10.1016/j.jmmm.2021.167951
- Elmekawy AA Mistonov, IS Dubitskiy, AHA Elmekawy, et al. (2021) Change in the Direction of the Easy Magnetization Axis of Arrays of Segmented Ni/Cu Nanowires with Increasing Ni Segment Length.Physics of the Solid State. doi: https://doi.org/10.1134/S1063783421070179

Compatibility of small angle neutron scattering and FORC method for studying magnetic behavior for arrays of 3D magnetic nanowires materials

Motivation

Increasing demand on new structure of magnetic material in the nanoscale to be used in definite devices and different applications [**1-5**], helped to increase number of studies in this domain. The novel electrochemical techniques allow for tuning diameter and pore density of anodic aluminium oxide, also controls the length of magnetic and nonmagnetic segments which show a great candidate for sensing and recording memory, spintronics, drug delivery and hyperthermia for medical applications.

Numerous studies focused on creating magnetic nanowires as a leading application in the field of nanotechnology for recording or information storage. Such systems needed to be created using complex synthesis techniques under ideal conditions that allowed for high stability and prevented data loss issues. More details about synthesis process could be found elsewhere [**6**].

We expect that SANS technique would help to realize change of geometrical parameter in our samples having different aspect ratios as it was realized before, revealing size effect on the nanoscale [**7**] even with two different scales.

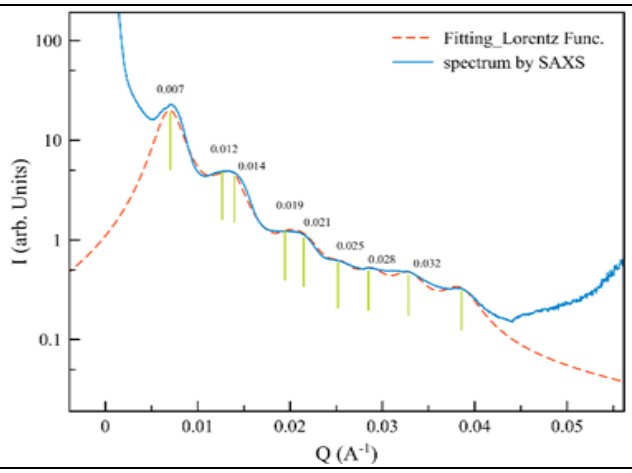
Background

Studying the magnetic behaviour for series of pure iron nanowire with different lengths and other series of segmented Cu-Ni nanowires with various repetition order by means of conventional SQUID magnetometry in addition to morphological characteristics on the macro and micro scale conducted by means of SEM, EDX. Also, SAXS analysis also was conducted for determination of the periodicity of the samples. The main goal was to investigate the impact of geometrical parameters (impact of length) on the magnetic behaviour of the samples, the first order reversal curve (FORC) analysis was applied for the pure iron samples for the first time.

Obtained results by FORC between two different samples (short / long length) was significant, FORC analysis help to reveal internal interactions during magnetization process. For our samples we planned to use Small Angle Neutron Scattering (SANS) analysis with and without applying external magnetic field along with the nanowire axis, seeing how the change of geometrical parameter should impact on the scattering curve on both situations, also seeing if it is possible to investigate kind of internal interactions and how it could be compatible with the results of FORC analysis. We expected that small angle neutron scattering should add more understanding to the magnetic behaviour which should be realized by using the 2D new detecting system on YuMO. With both methods a good characterization for the magnetic behaviour - which is of great importance for different applications - could be satisfied.

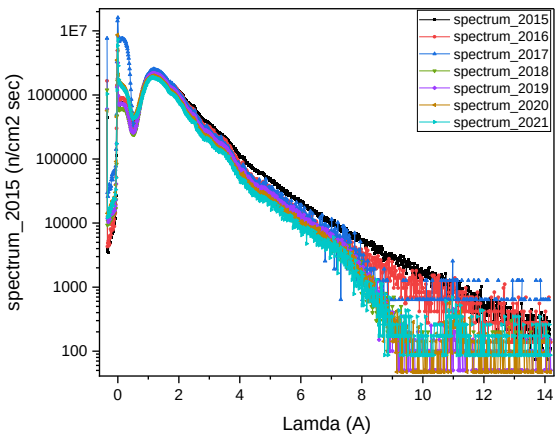
Achievements

- Training and studying basics of both SANS and SAXS techniques, processing previous experimental data using SAS, Sasview, and ATSAS package.
- Conducting one experiment onto SAXS (XENOCS) investigating periodicity of magnetic nanowire samples (CuNi – Fe) the results are summarized as follows.



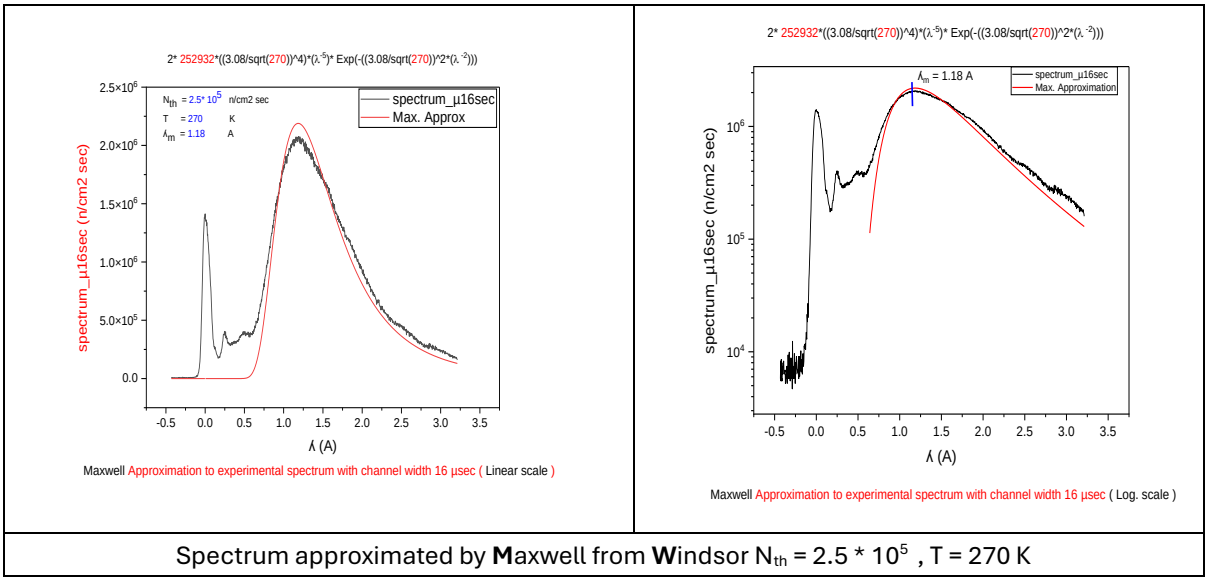
The periodicity of the nanowire arrangement was calculated from the reflection positions.
the samples represent a set of 2D hexagonally arranged pores of randomly oriented domains.
The average distance of pores / nanowires between the centers is 103 nm.

- Participating through the setting of the 2D PSD detector, electronical setup and testifying.
- Studying and analyzing the change of neutron spectrum within several cycles of the reactor since 2015, by processing the count obtained onto the direct beam detector DBD of the YUMO facility.



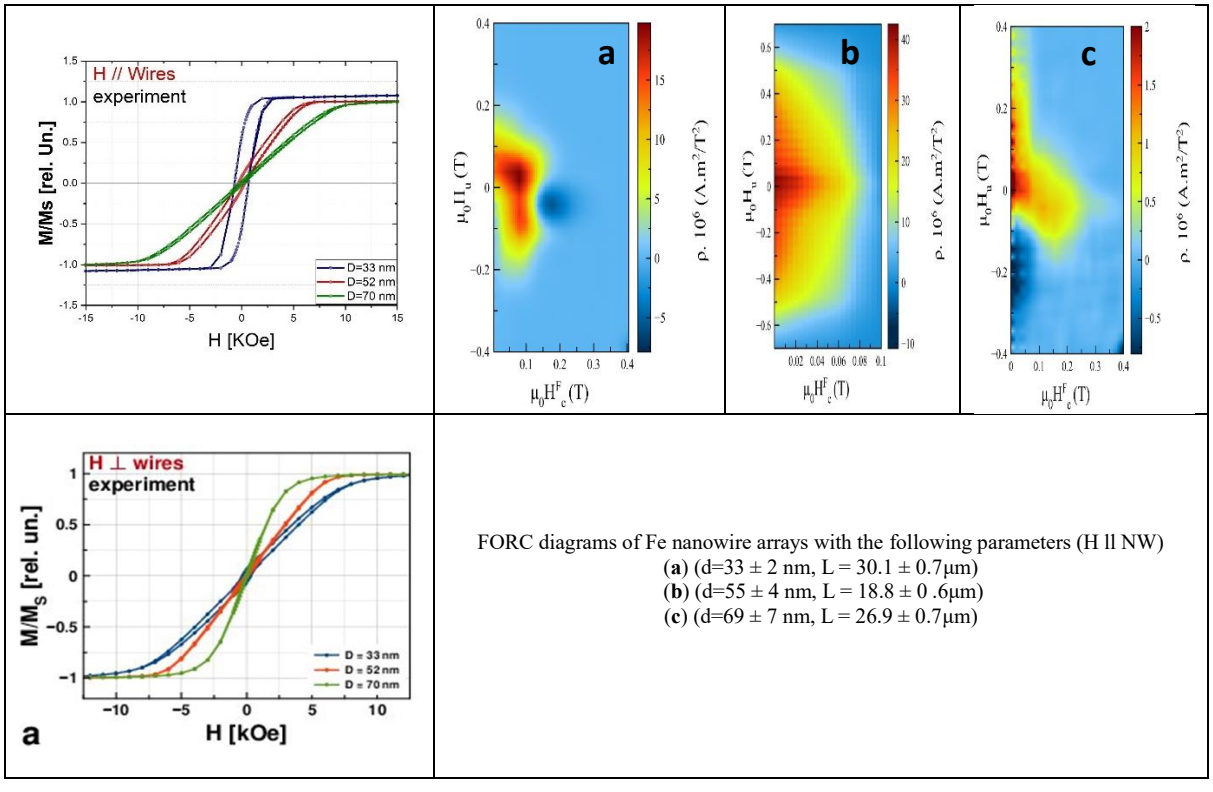
Change of spectrum with years since 2015 indicating how neutrons with higher wavelength could be noticed on first two years with reasonable dynamic factor also the effect of the chopper frequency alignment with the reflector periodicity.

- Studying and analyzing the neutron spectrum with channel time width of 16 μsec compared to other spectrum with standard 128 μsec channel width.



Spectrum approximated by **M**axwell from **W**indsor N_{th} = 2.5 * 10^5 , T = 270 K

- Participated in Scientific Forum (Physics 2024 – Samarkand) with Poster titled "**Magnetic characteristics of arrays of iron-based nanowires investigated by FORC Analysis**".



- Currently conducting SAXS analysis on Rigaku instrument (MIPT) for Powder samples of magnetic composite (Magnetite / Yttrium oxide) with different concertation (unfinished analysis).

Main direction of work next years

- Solving technical issues related to magnetic field system, applying suitable conditions to conduct SANS experiments with external magnetic applied parallel to nanowire axis for our samples and take a part in work upgrading position sensitive detector (PSD).
- Preparing new samples with new geometrical parameters (smaller diameters of 30 nm and Different length).
- Writing algorithm suitable for processing anisotropic pattern expected with our samples.
- Investigating possibility of enrolling used templates for Neutron focusing application.
- Preparing paper discussing the DBD efficiency.
- Preparing results of Magnetic Material (Nanowires / Powder) concerning size effect for publication.

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