11. International Conference on Polarised Neutrons for Condensed Matter Investigations (PNCMI-2016)

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Program and Abstract Booklet

Jülich Centre for Neutron Science

MLZ
Heinz Maier-Leibnitz Zentrum

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Welcome to PNCMI 2016

Dear colleagues,

The 2016 PNCMI (Polarised Neutrons for Condensed-Matter Investigations) International Conference continuous the successful previous conferences in this series covering he latest condensed-matter investigations using polarised neutrons and state-of-the-art methodologies, techniques of polarised-neutron production and utilisation for novel instrumentation and experiments, with emphasis on prospects for new science and new instrument concepts.

With over 110 registered partcipants PNCMI is the most comprehensive conference in this area. 22 invited presentations by renowned scientists, 37 contributed talks and over 40 poster presentations demonstrate the activities using polarized neutrons all over the world and show the deep interest in developing the topic. The presentations tackle all area of science including multiferroic and chirality, strongly correlated electron systems, superconductors, frustrated and disordered systems, magnetic nanomaterials, thin films and multilayers, soft matter and biology, imaging,polarized neutron techniques and methods, including nuclear polarisation, Larmor techniques, and depolarisation methods.

The conference is organized by the Jülich Centre for Neutron Science (JCNS) of the Forschungszentrum Jülich. The organizers gratefully acknowledge the financial support by J-PARC and AIRBUS DS as Premium Sponsors and Swiss Neutronics, ISIS, LLB, PSI and Mirrotron as Standard Sponsors of this conference and of the Heinz Maier-Leibnitz Zentrum (MLZ).

Proceedings of the conference will be published in Institute of Physics: Conference Series.

The organizers like to thank all partcipants and hope you all will enjoy a interesting conference.

Alexander Ioffe	Thomas Gutberlet
(Conference Chair)	(Organising Committee)

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PNCMI 2016 - Program

	Mo. 04.07.16		**Tu. 05.07.16**		**We. 06.07.16**		**Th. 07.07.16**
			Session 3 Imaging / Soft matter ***(P. Böni)***		**Session 7** Polarized neutron instrumentation ***(K. Habicht)***		**Session 11** Complementary techniques ***(A. van Well)***
		09:00 09:25 09:50 10:10 10:30	M. Strobl (ESS) M. Schulz (TUM) T. Shinohara (JPARC) H. Frielinghaus (JCNS) A. Savici (ORNL)	09:00 09:25 09:50 10:10 10:35	I. Zaliznyak (BNL) Y. Nambu (TohU) S. Mattauch (JCNS) R. Dalgliesh (ISIS) T. Saerbeck (ILL)	09:00 09:25 09:45 10:05	A. Petukhov (ILL) W.Kreuzpaintner(TUM) N. Pleshanov (PNPI) M. Enderle (ILL)
		10:50	Coffee break	10:55	Coffee break	10:25	Coffee break
10:00	**Registration**		**Session 4** Frustrated and quantum magnets ***(A. Michels)***		**Session 8** Strongly correlated electron systems II ***(R. Stewart)***		**Session 12** Neutron scattering facilities ***(M. Arai)***
		11:20 11:45 12:05 12:25	T. Fennel (PSI) J. Reim (TohU) F. Groitl (PSI) M. Skoulatos (TUM)	11:20 11:45 12:05 12:25	P. Bourges (LLB) T. Keller (MPI) B. Fak (ILL) F. Weber (KIT)	11:00 11:25 11:50 12:10 12:30 12:50	B. Märkisch (TUM) K. Kakurai (CROSS) L. He (CIAE) S. Mattauch (JCNS) X. Fabreges (LLB) Closing
12:00 12:50	Lunch Welcome	12:45	Lunch	12:50	Lunch	13:00	Lunch
	Session 1 Multiferroic and Chirality ***(K. Kakurai)***		**Session 5** Thin films and multilayers I ***(B. Toperverg)***		**Session 9** Polarized neutron techniques / Analysis ***(A. Ioffe)***		
13:00 13:25 13:50 14:10 14:30 14:50	D. Gilbert (NIST) M. Schmitz (JCNS) J.-H. Chung (Korea U) S. Grigoriev (PNPI) S. Mühlbauer (TUM) S.-A. Siegfried (HZG)	13:45 14:10 14:30 14:50 15:10	E. Kravtsov (IMP) A. Glavic (PSI) D. Lott (HZG) V. Tarnavich (PNPI) O. Holderer (JCNS)	13:45 14:10 14:35 14:55 15:15	W. Chen (NIST) W. Tung Lee (ANSTO) B. Winn (ORNL) E. Babcock (JCNS) G.Nielsen (ISIS)		
15:10	Coffee break	15:30	Coffee break	15:35	Coffee break		
	Session 2 Strongly correlated electron systems I ***(T. Brückel)***		**Session 6** Thin films and multilayers II ***(D. Lott)***		**Session 10** Polarized neutron techniques / NSE ***(O. Holderer)***		
15:40 16:05 16:30 16:50 17:15 17:35	P. Dai (Rice U) S. Nandi (ITK) W. Jin (JCNS) K. Ridier (GEMaC) A. Michels (ULux) Z. Fu (JCNS)	16:00 16:25 16:45 17:05 17:25	B. Toperverg (PNPI) R. Maruyama (JPARC) S. Mayr (TUM) Y. Khaydukov (MPI) A. Sved Mohd (JCNS)	16:05 16:30 16:55 17:15 17:35	B. Farago (ILL) A. van Well (TUD) K. Habicht (HZB) O.Ivanova (JCNS) M. Kotlarchyk (RIT)		
17:55	Poster session 1	17:45	Poster session 2	17:55	**18:30 Transfer to**		
20:00	Dinner	20:00	Dinner	20:00	**Workshop dinner**		

Abstracts

Oral and poster presentations

Mo. 04.07.2016

12:50 Welcome

Session 1 Multiferroic and Chirality

Session chair: Kazuhisa Kakurai (CROSS)

13:00(I) **Dustin A. GILBERT (NIST)**

Realization of Ground-State Artificial Skyrmion Lattices at Room Temperature

13:25(I) **Markus SCHMITZ (FZ Jülich)**

Strain and electric field mediated manipulation of magnetism in $La_{(1x)}Sr_xMnO_3$/BaTiO3 heterostructures

13:50 **Jae-Ho CHUNG (Korea University)**

Spherical neutron polarimetry study of spontaneous magnetic handedness reversal in multiferroic spiral magnet $Mn_{1-x}Ni_xWO_4$

14:10 **Sergey GRIGORIEV (PNPI)**

Hidden quantum phase transition in Mn1-xFexSi

14:30 **Sebastian MÜHLBAUER (TU Munich)**

Static and Quasi-Elastic Properties of the Spiral Magnet Ba2CuGe2O7 Studied by NRSE Spectroscopy

14:50 **Sven-Arne SIEGFRIED (HZG)**

Spin waves in full-polarized state of Dzyaloshinskii-Moriya helimagnets: Small-angle neutron scattering study

15:10 Coffe break

Session 2 Strongly correletaed electron systems I

Session chair: Thomas Brückel (JCNS)

15:40(I) **Pengcheng DAI (Rice University)**

Neutron Polarization Analysis of spin excitations in iron-based superconductors

16:05(I) **Shibabrata NANDI (Indian Institute of Technology Kanpur)**

Magnetic structure and magnetization densities of iron arsenide superconductors

16:30 **Wentao JIN (JCNS)**

Magnetic polarization of Ir in underdoped nonsuperconducting Eu(Fe0.94Ir0.06)2As2

16: 50(I) **Karl RIDIER (GEMaC, LLB)**

Polarized neutron diffraction as a tool for mapping molecular magnetic anisotropy: local susceptibility tensors in Co^{II} complexes

17:15 **Andreas MICHELS (University Luxemburg)**

Effect of Dzyaloshinski-Moriya interaction on spin-polarized neutron scattering: prediction of a polarization dependence of the spin-flip cross section

17:35 **Zhendong FU (JCNS)**

Field-Driven Self-Assembly of Magnetite Nanoparticles Investigated Using Small-Angle Neutron Scattering

17:55 **Poster session 1**

Tu. 05.07.2016

Session 3 Imaging / Soft matter

Session chair: Peter Böni (TU Munich)

09:00(I) **Markus STROBL (ESS)**

Spin-Echo Modulated Dark-Field Imaging

09:25(I) **Michael SCHULZ (TU Munich)**

Neutron Depolarization Imaging on weak ferromagnets

09:50 **Takenao SHINOHARA (J-PARC)**

Polarization analysis for Magnetic field imaging at RADEN in J-PARC/MLF

10:10 **Henrich FRIELINGHAUS (JCNS)**

The effect of amphiphilic polymers with a continuous philicity profile on the membrane properties in a bicontinuous microemulsions studied by neutron scattering

10:30 **Andrei SAVICI (ORNL)**

Data processing workflow for time of flight polarized neutrons inelastic measurement

10:50 Coffee break

Session 4 Frustrated and quantum magnets

Session chair: Andreas Michels (Uni Luxemburg)

11:20(I) **Tom FENNEL (PSI)**

Spin correlations and magnetoelastic excitations in Tb2Ti2O7

11:45 **Johannes Reim (Tohoku University)**

Skyrmion-lattice like spin structure in a layered kagome system

12:05 **Felix GROITL (PSI)**

Anomalous thermal decoherence in a quantum magnet measured with neutron spin-echo spectroscopy

12:25 **Markos SKOULATOS (TU Munich)**

Emergent phases and frustration in model magnets

12.45 Lunch

Session 5 Thin films and multilayers I

Session chair: Boris Toperverg (PNPI)

13:45(I) **Evgeny KRAVTSOV (Inst. of Metal Physics)**

Complementary application of polarized neutron and resonant x-ray reflectometry to probe magnetic order in metallic multilayers

14:10 **Artur GLAVIC (PSI)**

Experimental evidence for FM/AFM interlayer exchange coupling from polarized neutron reflectometry and neutron diffraction

14:30 **Dieter LOTT (HZG)**

Chirality induced exchange bias effect in DyCo/FeNi bilayers investigated by polarized neutron reflectometry

14:50 **Vladislav TARNAVICH (PNPI)**

Sign-changing chirality in Ho/Y multilayers

15:10 **Olaf HOLDERER (JCNS)**

Grazing incidence NSE with advanced optical components

15:30 Coffee break

Session 6 Thin films and multilayers II

Session chair: Dieter Lott (HZG)

16:00(I) **Boris TOPERVERG (PNPI)**

PNR from laterally patterned spin-valves

16:25 **Ryuji MARUYAMA (J-PARC)**

Study of the in-plane magnetic structure of a layered system using polarized neutron off-specular and grazing-incidence small-angle scattering

16:45 **Sina MAYR (TU Munich)**

Fe Layer Induced Ferromagnetism in Pd: An In-Situ Polarised Neutron Reflectometry Study

17:05 **Yuri KHAYDUKOVB (MPI)**

Magnetic waveguides in polarized neutron reflectometry of oxide heterostructures

17:25 **Amir SYED MOHD (JCNS)**

Growth and interfacial properties of FePt/Fe/NiO and FePt/NiO/Fe trilayers

17:45 **Poster Session 2**

We. 06.07.2016

Session 7 Polarized neutron instrumentation

Session chair: Klaus Habicht (HZB)

09:00(I) **Igor ZALIZNYAK (BNL)**

Polarized inelastic neutron scattering on Hybrid Spectrometer at SNS

09:25(I) **Yusuke NAMBU (Tohoku University)**

Magnetism of the triangular antiferromagnet $NiGa_2S_4$ and introduction of POLANO

09:50 **Stefan MATTAUCH (JCNS)**

MARIA – The high-intensity polarized neutron reflectometer of JCNS

10:10(I) **Robert DALGLISH (ISIS)**

Larmor: A flexible instrument for SANS, Polarised SANS and Larmor precession techniques

10:35 **Thomas SAERBECK (ILL)**

Time-of-flight and monochromatic polarized neutron reflectometry on D17 at ILL

10:55 Coffee break

Session 8 Strongly correletaed electron systems II

Session chair: Ross Stewart (ISIS)

11:20(I) **Philippe BOURGES (LLB)**

Q=0 Magnetic order in the pseudogap state of cuprates superconductors

11:45 **Thomas KELLER (MPI)**

Magnetostriction and magnetostructural domains in antiferromagnetic YBa2Cu3O6

12:05 **Björn FÅK (ILL)**

Magnetic structure of the noncentrosymmetric heavy-fermion superconductor CePt3Si

12:25(I) **Frank WEBER (KIT)**

Magnetic moments induce strong phonon renormalization in FeSi

12:50 Lunch

Session 9 Polarized neutron techniques / Analysis

Session chair: Alexander Ioffe (JCNS)

13:45(I) **Wangchun CHEN (NIST)**

Polarized neutron developments and applications at the NIST Center for Neutron Research

14:10(I) **Wai Tung LEE (ANSTO)**

Polarised Neutron Instrumentation and Scientific Experiments at ANSTO

14:35 **Barry WINN (ORNL)**

3D Polarization Analysis with a Polarizing Supermirror Array Analyzer at HYSPEC

14:55 **Earl BABCOCK (JCNS)**

Polarized 3He neutron spin filter for PA studies at the JCNS

15:15 **Goran NILSEN (ISIS)**

Polarization analysis on the LET direct geometry time-of-flight spectrometer

15:35 Coffee break

Session 10 Polarized neutron techniques / NSE

Session chair: Olaf Holderer (JCNS)

16:05(I) **Bella FARAGO (ILL)**

The IN15 upgrade and first results

16:30(I) **Ad van WELL (TU Delft)**

Larmor neutron diffraction with one precession arm

16:55 **Klaus HABICHT (HZB)**

MIEZE Larmor Diffraction

17:15 **Oxana IVANOVA (JCNS)**

J-NSE: recent scientific and instrumental developments

17:35 **Michael KOTLARCHYK (RIT)**

A framework for modeling polarized neutron scattering from NMR spin-modulated systems

18:30 Transfer to conference dinner

Th. 07.07.2016

Session 11 Complementary techniques

Session chair: Ad van Well (TU Delft)

09:00(I)	**Alexander PETUKHOV (ILL)** Toward a broad-band neutron polarizer with flipping-ratio of thousands
09:25	**Wolfgang KREUZPAITNER (TU Munich)** In-Situ Polarised Neutron Reflectometry during Thin Film Growth
09:45	**Nikolay PLESHANOV (PNPI)** First neutron mirror spin flipper: experiment, perspectives
10:05	**Mechthild ENDERLE (ILL)** Progress in Parallel Polarisation Analysis
10:25	Coffee break

Session 12 Neutron scattering facilities

Session chair: Masatoshi Arai (ESS)

11:00(I)	**Bastian MÄRKISCH (TU Munich)** Measurements with Polarised Neutrons in Neutron Beta Decay
11:25(I)	**Kazuhisha Kakurai (CROSS)** Polarized neutron activities at the J-PARC Materials and Life Science Facility - An Overview
11:50	**Lifeng HE (CIAE)** The current status of facilities at China Advanced Research Reactor
12:10	**Stefan MATTAUCH (JCNS)** Polarized neutron sctivities at the JCNS
12:30	**Xavier FABREGES (LLB)** MAGiC: the polarized single crystal diffractometer at ESS
12:30	Closing remarks
13:00	Lunch

Monday 04.07.16, 13:00

Realization of Ground-State Artificial Skyrmion Lattices at Room Temperature

Dustin A. GILBERT[1,2], Brian B. MARANVILLE[2], Andrew L. BALK[3,4], Brian J. KIRBY[2], Peter FISCHER[5,6], Daniel T. PIERCE[3], John UNGURIS[3], Julie A. BORCHERS[2] & Kai LIU[1]

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Magnetic skyrmions exhibit topologically protected quantum states, not only offering exciting new mechanisms for ultrahigh density and low dissipation information storage, but also providing an ideal platform for explorations of unique topological phenomena. Here, we demonstrate the realization of artificial Bloch skyrmion lattices over extended areas in their ground state at room temperature by patterning asymmetric magnetic nanodots with controlled circularity on an underlayer film with perpendicular magnetic anisotropy (PMA) [1]. The chiral structure is imprinted from the Co dots into the Co/Pd multilayer underlayer by selectively suppressing the PMA under the dots via a critical ion irradiation step.

Demonstration of the dot circularity was provided by magnetometry and direct imaging using SEMPA, MFM, and MTXM. Polarity is controlled by a tailored magnetic field sequence and demonstrated by magnetometry. Key to this work was demonstrating the imprinting of the chiral structure into the underlayer film. The imprinted skyrmion structure, buried underneath the nanodots, was directly probed by specular and off-specular polarized neutron reflectometry and confirmed by magnetoresistance measurements. Due to the limited lateral coherence of the incident neutron wave packet, analysis of the resulting reflectivity from the large 560 nm diameter dots required use of an incoherent sum of scattering potentials from different regions of the nanodot. Based on the specular reflectometry profile a micromagnetic model was generated which accurately reproduced the physical system. Using the Born approximation, the expected off-specular reflectometry was calculated and compared to the experimental measurements. This analysis reveals that the imprinted Co vortex structure is shown to only extend as deep as the irradiation damage into the Co/Pd underlayer. Our results demonstrate an exciting platform to explore Bloch skyrmion lattices in ambient conditions.

[1] D. A. Gilbert, *et al.*, Nature Commun., **6**, 8462 (2015).

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Monday 04.07.16, 13:25

Strain and electric field mediated manipulation of magnetism in $La_{(1-x)}Sr_xMnO_3$/BaTiO3 heterostructures

Markus SCHMITZ[1], Alexander WEBER[2], Paul ZAKALEK[1], Markus WASCHK[1], Thomas BRÜCKEL[1]

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The understanding and manipulation of strong correlated electron systems in complex oxides has attracted much interest in the broad realm of solid state physics due to the large amount of possible applications. The combination of a strong ferromagnetic and a ferroelectric material can lead to an artificially multiferroic system via the coupling at the common interface. Heterostructures of La1-xSrxMnO_3 and BaTiO_3 were produced by an oxide molecular beam epitaxy and a high pressure oxygen sputtering system. The magnetic properties were investigated following a theoretically predicted magneto-electric effect by Burton et al. [1]. By the use of BaTiO_3 substrates the influence of strain on the magnetic properties in the LSMO film could be determined. Even more fascinating is the manipulation of the magnetization by the application of external electric fields which could be shown by the use of a SQUID magnetometer. Here, the magnetic response to an applied electric field could be determined by using a newly established measurement option as function of temperature and magnetic field [2]. Additionally, the magnetic profiles of the samples were characterized by polarized neutron reflectometry measurements in order to clarify a limitation of the effects to the interface.

[1] J. D. Burton and E. Y. Tsymbal, Physical Review B, **80**, 174406–1–174406–6 (2009).

[2] P. Borisov, A. Hochstrat, V. V. Shvartsman, and W. Kleemann, Review of

Scientific Instruments, **78,** 106105 (2007).

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Monday 04.07.16, 13:50

Spherical neutron polarimetry study of spontaneous magnetic handedness reversal in multiferroic spiral magnet $Mn_{1-x}Ni_xWO_4$

Yong Sang SONG[1,2], **Jae-Ho CHUNG[1]**, Jonathan WHITE[3], Bertrand ROESSLI[3]

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[2]Max Planck POSTECH, Pohang, South Korea

[3]Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, Villigen, Switzerland

In magnetoelectric multiferrics, the ferroelectricity may arise due to long-range magnetic ordering with broken inversion symmetry. Signs of such ferroelectric polarizations are determined by the chirality of the underlying magnetic ordering, or handedness of spiral spin structures. $MnWO_4$ is a well-known multiferroic oxide exhibiting an antiferromagnetic phase with the spiral spin structure. The direct relation between its magnetic handedness and the ferroelectricity has been previously confirmed [1]. In our previous work, we observed spontaneous ferroelectric sign reversal in Ni-doped $MnWO_4$ single crystals that appeared during temperature increase under zero external fields [2]. In this talk, we report new spherical neutron polarimetry results confirming that the reversal of magnetic handedness is indeed responsible for the observed ferroelectric sign reversal. We will also present doping dependence of heliconical spin structures, which provides us with an important insight in understanding the mechanism of the spontaneous reversal in magnetic handedness.

[1] H. Sagayama, K. Taniguchi, N. Abe, T. Arima, M. Soda, M. Matsuura, and K. Hirota, Phys. Rev. B **77**, 220407(R) (2008).

[2] Y.-S. Song, J.-H. Chung, K. W. Shin, K. H. Kim, and I. H. Oh, Appl. Phys. Lett. **104**, 252904 (2014).

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Monday 04.07.16, 14:10

Hidden quantum phase transition in $Mn_{1-x}Fe_xSi$

Sergey V. GRIGORIEV[1,2], Evgeny V. MOSKVIN[1,2], Vadim A. DYADKIN[1,3], Nadezhda M. CHUBOVA[1], Charles DEWHURST[4], Dirk MENZEL[5], Sergey V. DEMISHEV[6]

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The cubic B20-type compounds (MnSi, etc) are well known for the incommensurate magnetic structures with a very long period appeared due to noncentrosymmetric arrangement of magnetic atoms. The helix spin structure and order-disorder phase transition have been studied in the isostructural solid solutions $Mn_{1-x}Fe_xSi$ (with $x = 0.0 – 0.2$) by means of polarized neutron small angle scattering. The substitution of manganese by iron in $Mn_{1-x}Fe_xSi$ suppresses the helical spin state. The neutron scattering studies [1,2] together with magnetic data and specific heat measurements [3] discovered a quantum critical point (QCP) corresponding to the suppression of the spin spiral phase with long-range order (LRO) in $Mn_{1-x}Fe_xSi$. This QCP located at $x_{c1} \approx 0.11$ - 0.12 is, however, hidden by a spin helix short-range order (SRO) [2, 3]. This SRO phase is destroyed at the second QCP $x_{c2} \approx$ 0.24. Thus it has been shown that $Mn_{1-x}Fe_xSi$ undergoes a sequence of the two quantum phase transitions [3]. The real breakthrough in understanding of the abovementioned experimental facts has been done via scrutinizing the Hall effect in $Mn_{1-x}Fe_xSi$ [4]. It was found that the substitution of Mn with Fe results rather in the hole doping opposite to the natural expectations on the electron doping. The two groups of the charge carriers contribute to the Hall effect and the ratio between them changes the sign of the Hall effect constants at $x_{c1} \approx 0.11$, what is definitely associated with the QCP in these compounds.

[1] S.V. Grigoriev, V.A. Dyadkin, E.V. Moskvin, *et al*, Phys.Rev. B 79, 144417 (2009).

[2] Sergey V. Grigoriev, Evgeny V. Moskvin, *et al*, Phys.Rev. B, 83 (2011) 224411.

[3] S.V. Demishev, I.I. Lobanova, V.V. Glushkov, *et al*, JETP Lett., 98 (2014) 829.

[4] V.V. Glushkov, I. I. Lobanova, V. Yu. Ivanov, *et al*, Phys.Rev. Lett. 115 (2015) 256601.

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Monday 04.07.16, 14:30

Static and Quasi-Elastic Properties of the Spiral Magnet $Ba_2CuGe_2O_7$ Studied by NRSE Spectroscopy

Sebastian MÜHLBAUER[1], Jonas KINDERVATER[2],Wolfgang HÄUSSLER[1,2]

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[2]Physikdepartment, Technische Universität München, D-85748 Garching,

We provide a novel route to use neutron spin echo spectroscopy (Larmor labeling) for a unified approach to study both static and dynamic properties of incommensurate magnetic structures with small propagation vectors [1]. The archetypal non-centrosymmetric spiral magnet $Ba_2CuGe_2O_7$ serves as a model system for our study [2,3]. We show how Larmor labeling can efficiently decouple instrumental wavelength-resolution and effective **Q**-resolution and give a high precision access to the structural properties of the incommensurate domains of $Ba_2CuGe_2O_7$:

We theoretically consider the general case of elastic and quasi-elastic neutron spin echo measurements from incommensurate helical, cycloidal and elliptical magnetic structures. As the resolution in **Q**-space of a typical neutron spin echo spectrometer is limited by the velocity selector mostly used on such instruments, we in particular consider the interference effects, which arise due to the overlap of multiple incommensurate domains. A characteristic beating of the spin echo signal as function of precession field is expected by theory. This beating allows efficiently decoupling instrumental wavelength resolution and effective **Q**-resolution and gives a highly precise access to the structural properties of incommensurate domains.

[1] S. Mühlbauer, J. Kindervater and W. Häußler, *Phys. Rev. B* ***92****, 224406 (2015)*

[2] S. Mühlbauer, et al., *Phys. Rev. B.* ***86****, 024417 (2012)*

[3] S. Mühlbauer, et al., *Phys. Rev. B* ***84****, 180406(R) (2011)*

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Monday 04.07.16, 14:50

Spin waves in full-polarized state of Dzyaloshinskii-Moriya helimagnets: Small-angle neutron scattering study

Sergey V. Grigoriev[1,2], Alexander Sukhanov[1,2], Evgeniy Altynbaev[1,2], **Sven-Arne SIEGFRIED**[3], Andre Heinemann[3], Sergey V. Maleyev[1]

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The competition between the ferromagnetic exchange interaction J and the antisymmetric Dzyaloshinskii-Moriya (DM) interaction D leads to appearance of the helical magnetic structure in the cubic B20-type compounds. The external magnetic field H_{C2} is needed to transform the helix with wave vector $|\mathbf{k}_s| = D/J$ into the ferromagnetic collinear full-polarized (FP) state [1]. Despite of parallel ordering of the spins in the FP state, presence of the DM interaction leads to the chirality of the dispertion relation of the spin waves. The dispersion relation in this case can be written as follows: $\varepsilon_\mathbf{q} = A(\mathbf{q} - \mathbf{k}_s)^2 + H - H_{C2}$, where A is the spin-wave stiffness [2]. To verify the main peculiarities of the helimagnon spectrum in the FP state we have applied small angle scattering of polarized neutrons (SANS). MnSi crystal was chosen for this study as one of the best-known representatives of the DM helimagnets. We have shown that the cross section contains a polarization-dependend part due to the asymmetry of the aforementioned dispertion relation. The last means that the scattering on spin-waves in the FP state of helimangets can be distinguished by the substraction of the measured intensities with the different polarization of the incident netrons from each other: $I^{SW}(\theta) = I(\theta;+P_0) - I(\theta;-P_0)$. As can be seen, the inelastic scattering of neutrons on magnons appears mostly around the former Bragg peak in the small angles estimated to be less than $\theta_0 = \hbar/(2m_nA)$, where m_n is the mass of the neutron. By analyzing SANS maps, one can extract the value of the spin-wave stiffness of the system. We have shown that the spin-wave stiffness A for MnSi helimagnet decreased twice as the temperature increases from zero to the critical temperature T_C [3].

[1] P. Bak, M. H. Jensen, J. Phys. C, **13**, L881 (1980).

[2] M. Kataoka, J. Phys. Soc. Jpn., **56**, 3635 (1987).

[3] S. V. Grigoriev et al., Phys. Rev. B, **92**, 220415(R) (2015).

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Monday 04.07.16, 15:40

Neutron Ploarization Analysis of spin excitations in iron-based superconductors

Pengcheng DAI

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In this talk, I will present our recent polarized neutron scattering studies of spin excitations in iron-based superconductors. Compared with unploarzed neutrons, neutron polarization analysis can provide some unique information concerning the magnitude of spin excitations along different directions. We will summarize progress made in the field of iron-based superconductors over the past several years, and discuss future prospect of using polarized neutrons to study correlated electron materials.

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Monday 04.07.16, 16:05

Magnetic structure and magnetization densities of iron arsenide superconductors

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Superconductivity and magnetism are two antagonistic phenomena since the superconducting state expels external magnetic flux. However, using x-ray resonant magnetic scattering and neutron scattering techniques, we show that superconductivity and ferromagnetism coexists in the $EuFe_2(As_{1-x}P_x)_2$ family. Rather than the nature of long range magnetic order (ferromagnetic or antiferromagnetic), polarized and unpolarized neutron diffraction measurements also reveal site specific magnetization distribution of the Fe moments. Detail modeling of the magnetic form factor indicates the presence of an orbital moment to the total paramagnetic moment of Fe^{2+} and might be responsible for the anisotropic properties of the pnictides.

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Monday 04.07.16, 16:30

Magnetic polarization of Ir in underdoped nonsuperconducting $Eu(Fe_{0.94}Ir_{0.06})_2As_2$

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Using polarized neutron diffraction and x-ray resonant magnetic scattering (XRMS) techniques, multiple phase transitions were revealed in an underdoped, nonsuperconducting $Eu(Fe_{1-x}Ir_x)_2As_2$ (x = 0.06) single crystal [1]. Compared with the parent compound $EuFe_2As_2$, the tetragonal-to-orthorhombic structural phase transition and the antiferromagnetic order of the Fe^{2+} moments are significantly suppressed to T_S = 111(2) K and $T_{N,\ Fe}$ = 85(2) K by 6% Ir doping, respectively. In addition, the Eu^{2+} spins order within the *ab* plane in the A-type antiferromagnetic structure similar to the parent compound [2]. However, the order temperature is evidently suppressed to $T_{N,\ Eu}$ = 16.0(5) K by Ir doping. Most strikingly, the XRMS measurements at the Ir L_3 edge demonstrates that the Ir 5*d* states are also magnetically polarized, with the same propagation vector as the magnetic order of Fe. With $T_{N,\ Ir}$ = 12.0(5) K, they feature a much lower onset temperature compared with $T_{N,\ Fe}$. Our observation suggests that the magnetism of the Eu sublattice has a considerable effect on the magnetic nature of the 5*d* Ir dopant atoms and there exists a possible interplay between the localized Eu^{2+} moments and the conduction *d* electrons on the FeAs layers.

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Monday 04.07.16, 16:50

Polarized neutron diffraction as a tool for mapping molecular magnetic anisotropy: local susceptibility tensors in Co^{II} complexes

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Research in molecular magnetism has motivated a growing interest for the study of magnetic anisotropy in molecular complexes since a strong axial anisotropy is required for potential applications like high-density data storage at the nanoscale. For this purpose, we used polarized neutron diffraction (PND) combined with the so-called local site susceptibility tensor approach [1]. We report here the PND studies performed on two six-coordinated Co^{II} molecular complexes: a mononuclear complex $[Co(DMF)_6](BPh_4)_2$ [2] and a dinuclear complex $[Co_2(\textit{sym}\text{-hmp})_2](BPh_4)_2$ [3].

The local site susceptibility tensor approach enables a unique determination of the local susceptibility tensor of each magnetic atom in the unit cell. In the mononuclear complex, we find that the local easy magnetization axis is clearly related to a trigonal elongation axis of the coordination octahedron of the Co^{II} ion [4]. For the dinuclear complex, the determination of the individual Co^{II} magnetic susceptibility tensors provides a clear outlook of how the local magnetic properties on both Co sites deviate from the single-ion behavior because of antiferromagnetic exchange coupling. This study demonstrates the capabilities of PND to provide a unique and straightforward picture of the magnetic anisotropy, offering a clear-cut way to establish magneto-structural correlations in paramagnetic molecular complexes.

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Monday 04.07.16, 17:15

Effect of Dzyaloshinski-Moriya interaction on spin-polarized neutron scattering: prediction of a polarization dependence of the spin-flip cross section

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For magnetic materials containing many lattice imperfections (e.g., nanocrystalline magnets), the relativistic Dzyaloshinski-Moriya (DM) interaction may result in nonuniform spin textures due to the lack of inversion symmetry at interfaces. Within the framework of the continuum theory of micromagnetics, we explore the impact of the DM interaction on the elastic magnetic small-angle neutron scattering (SANS) cross section of bulk ferromagnets. It is shown that the DM interaction gives rise to a polarization-dependent term in the spin-flip SANS cross section.

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Monday 04.07.16, 17:35

Field-Driven Self-Assembly of Magnetite Nanoparticles Investigated Using Small-Angle Neutron Scattering

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The magnetic-field-assisted superstructure formation of magnetic nanoparticles provides a unique and flexible strategy in the design and the fabrication of functional nanostructures and devices.[1] In our study Fe_3O_4 nanoparticles have been characterized by using TEM, bulk magnetization, and small angle neutron scattering (SANS) methods. The Fe_3O_4 nanoparticles are found to be spherical in shape with an average diameter of about 21 nm. They show superparamagnetic behaviour, indicative of the single-domain nature of these magnetic particles. The core-shell microstructure of the Fe_3O_4 nanospheres has been investigated quantitatively using SANS of polarized neutrons on KWS-1 at MLZ. The field-driven self-assembly of these magnetic nanospheres has been evidenced by the clear diffraction peaks on the 2D SANS patterns. The diffraction pattern can be well indexed using a face-centred-cubic type of superstructure. The in situ formation of the magnetic particle aggregations under varying fields has been investigated by means of very small angle neutron scattering (VSANS) on KWS-3 at MLZ. We show that large-scale aggregations already start to develop at a low field of 0.02 T. The superiority of the SANS technique in studying self-assembly phenomena in solution is highlighted.

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Tuesday 05.07.16, 09:00

Spin-Echo Modulated Dark-Field Imaging

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While qualitative dark-field imaging with neutrons based on a spatial beam modulation achieved by a grating interferometer [1] has proven to be highly successful in the detection of inhomogeneous structural features beyond image resolution [2] as well as for the direct visualization of magnetic domains [3], only recently its quantitative exploitation with respect to small-angle scattering (SAS) information could be established [4]. At the same time an alternative approach to implement beam modulation through the application of spin-echo principles was introduced [5], could first be demonstrated to be applicable for quantitative SAS studies [6] and subsequently also for quantitative SAS imaging, i.e. spin echo modulated neutron dark-field imaging [7]. The advantage of such approach lies in the potential to exploit the highly efficient time-of-flight approach and correspondingly the brightest neutron sources for such flux limited studies. However, the yet relatively large modulation periods achieved somewhat limit the spatial resolution of this novel imaging technique to the mm range, while in contrast to grating based DF imaging, which operates in the micrometer range, it currently operates in the nanometer range. The challenges currently hence lie on the one hand in tuning the modulations implied to smaller periods and to on the other hand establish techniques to detect modulations with smaller periods in order to close or at least minimize the gaps in resolved length scales. The current state of the art and developments as well as potential applications and application examples shall be introduced.

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Tuesday 05.07.16, 09:25

Neutron Depolarization Imaging on weak ferromagnets

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In recent years radiography with polarized neutrons is increasingly being recognized as a powerful method for the investigation of magnetic field distributions, most notably of internal magnetic fields in bulk materials and trapped flux in superconductors [1-3]. As a special application of this technique, neutron depolarization imaging (NDI) is based on the measurement of the change of the neutron beam polarization after transmission of a ferromagnetic sample. In ferromagnetic materials the interaction of the neutron's nuclear magnetic moment μ with the magnetic field distributions in the domains leads to a depolarization of the neutron beam, resulting in an imaging contrast. Contrary to this, paramagnetic and antiferromagnetic materials do not change the beam polarization. Yielding a spatially resolved image of the ferromagnetic regions in a bulk material this technique has the advantage of being fast and non-destructive. Particularly in doped ferromagnetic or superconducting samples with a tendency to show inhomogeneous magnetic behavior over the sample size, the magnetic properties at different positions can be directly investigated and compared without the tedious and destructive preparation of single pieces for bulk measurements. In this context even a 3D tomographic reconstruction of the magnetic properties is possible [4]. Recently the NDI technique has been extended towards the investigation of materials under hydrostatic pressure. Additionally, we have upgraded our setup to allow for measurements under applied magnetic field.

In our presentation we will give an introduction to the neutron depolarization imaging technique and show various applications on weakly ferromagnetic material systems at temperatures as low as 50mK and pressures up to 40kbar.

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Tuesday 05.07.16, 09:50

Polarization analysis for Magnetic field imaging at RADEN in J-PARC/MLF

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Polarized neutron imaging is an attractive method to visualize magnetic fields in a bulk object or space. In this technique polarization of neutrons transmitted through a sample is analyzed position by position and produce an image of polarization distribution. Usage a pulsed neutron beam is very effective to evaluate both field strength and direction by means of the analysis of wavelength dependent polarization and enables us to convert the polarization distribution into the magnetic field distribution image [1]. Recently a new imaging instrument “RADEN” has been constructed at the beam line of BL22 of the Materials and Life Science Experimental Facility (MLF) at J-PARC, which is dedicated to the energy-resolved neutron imaging experiments [2]. In this instrument, polarization analysis apparatus for magnetic field imaging has been installed and the commissioning study has been going.

This polarization analysis apparatus of RADEN consists of a set of polarizers using magnetic supermirrors, a spin flipper and a spin rotation system with a magnetic shield chamber. The polarizer and the analyzer are designed to polarize neutrons with wavelength longer than 1.5 Å and their cross section are 50 x 50 mm^2. The spin rotation system for 3D polarization analysis, which is composed of two pairs of orthogonally arranged rectangular coils, is fully applicable to time-of-flight experiments by using magnetic fields ramping down synchronized with the neutron generation. Spatial distribution of neutron polarization was confirmed to be uniform. The polarization degree reached to 90 % at the wavelength longer than 2.5 Å and to maximum value of 97% at 5.0Å. As a demonstration study, a ring-shaped electric steel was measured and an oscillatory behavior was clearly observed in the wavelength dependence of neutron polarization. The period of polarization oscillation corresponded with that expected from the magnetization of the sample. In addition, a change of domain structure was observed by changing the applied field to the steel sample.

In this paper we introduce our new system and show recent results on polarized neutron imaging experiments.

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Tuesday 05.07.16, 10:10

The effect of amphiphilic polymers with a continuous philicity profile on the membrane properties in a bicontinuous microemulsions studied by neutron scattering

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Wherever surfactants are applied, it is of general interest to use as little surfactant as possible. However, in e.g. microemulsion systems increasing the solubilization capacity of an amphiphilic mixture is always accompanied by the formation of liquid crystalline mesophases. Integrating amphiphilic block copolymers (so called efficiency boosters) into the amphiphilic film leads to a considerable increase of the efficiency. This effect is mainly due to an increase of the bending rigidity of the amphiphilic film due to the presence of polymer domains on either side of the film. The formation of liquid crystalline mesophases was found to be suppressed at low concentrations of block copolymers, while it was enhanced at high concentrations. To break this trade-off between surfactant efficiency and the stabilization of liquid crystalline phases we studied a new class of amphiphilic polymers - so called tapered polymers - following the amphiphilicity profile going from diblock via triblock to continuously tapered [1]. In contrast to the commonly used diblock or triblock copolymers the molecular structure of tapered polymers gradually changes from hydrophilic to hydrophobic. The influence of this new class of polymers on the properties of microemulsion systems was investigated by systematic phase behaviour studies, SANS (small angle neutron scattering) and NSE (neutron spin echo) experiments. These measurements reveal that the polymers cause a stiffening of the amphiphilic film while simultaneously the saddle splay modulus increases considerably less such that the formation of liquid crystalline mesophases is suppressed while bicontinuous structures are geometrically favored. In addition, these findings are supported by theoretical calculations following the works of Lipowsky [2]. Hence tapered amphiphilic polymers not only increase the efficiency of surfactants, but simultaneously suppress the formation of liquid crystalline phases, and, thereby, greatly increasing their application potential.

The underlying NSE experiments for this interpretation rely on smallest changes of the relaxation curves (of ca. 1% steps) for still small changes of the bending rigidity (of ca. 10% steps). This high reliability of the experiments conducted at the SNS-NSE displays the accuracy of the instrument itself and the latest developments of the evaluation software, which were necessary to interpret such tiny changes of the bending rigidity reliably.

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Tuesday 05.07.16, 10:30

Data processing workflow for time of flight polarized neutrons inelastic measurement

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Extracting the spin-dependent cross-section from polarized neutron scattering experiments for instruments with single detectors is a relatively straightforward process. For instruments with multiple detectors, and especially for time-of-flight measurements, there are additional factors that must be taken into account, such as polarizer transmission and neutron beam deflection by the polarizer, both as a function of detector position and final energy. In addition, for each detector the neutron polarization has a different orientation with respect to the momentum transfer.

We present our data processing workflow for measurements performed at HYSPEC [1] spectrometer at the Spallation Neutron Source, Oak Ridge National Laboratory. The implementation is done using the Mantid [2] software package. We are going to review ongoing and future work regarding the polarized neutron scattering data analysis and modeling on multi-detector instruments.

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Tuesday 05.07.16, 11:20

Spin correlations and magnetoelastic excitations in $Tb_2Ti_2O_7$

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In the rare earth pyrochlore $Tb_2Ti_2O_7$, a three-fold puzzle exists - the mechanism by which $Tb_2Ti_2O_7$ escapes both magnetic order and/or a structural distortion, and furthermore, the nature of the spin liquid which exists instead, are long standing questions in the field of frustrated magnetism. Using polarized neutron scattering we have recently shown that at low temperature $Tb_2Ti_2O_7$ has power-law correlations, manifested by pinch point scattering, somewhat similar to a spin ice [1]. We have also discovered that an acoustic phonon is coupled to an excited crystal field state, producing a hybrid excitation with both propagating spin and phonon components - a magnetoelastic mode [2]. These results imply that the Hamiltonian of $Tb_2Ti_2O_7$ must incorporate both spin and lattice degrees of freedom, and that it must produce a type of Coulomb phase. I will review the subject of Tb2Ti2O7 in the context of frustrated magnetism, and present some results from recent polarized inelastic neutron scattering experiments that extend considerably our understanding of the magnetoelastic mode [3].

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Tuesday 05.07.16, 11:45

Antiferromagnetic skyrmion-lattice like spin structure in a layered kagome system

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Since the observation of topologically protected spin swirlings called skyrmions in non-centrosymmetric ferromagnets, such a lattice has been successfully stabilized in various bulk compounds in a small pocket of the magnetic field vs. temperature phase diagram. Recent theoretical studies even propose the existence of antiferromagnetic skyrmions.

The layered kagome system in the swedenborgite structure [1] displays similarly to the pyrochlores a highly frustrated network of tetrahedral coordinated magnetic ions. However, its broken inversion symmetry raises further the complexity of ordering due to Dzyaloshinski-Moriya (DM) interactions.[2,3] The crystallographic structure of $CaBaCo_2Fe_2O_7$ was refined in $P6_3mc$ symmetry and determined to be structural invariant.[4] The AF ordering observed below $T_N \approx 160$K can be described with a simple Heisenberg model.[3] Using polarization analysis a gradual spin reorientation with temperature and from the chiral interference a cycloidal character can be concluded. At low temperatures, high resolution diffraction reveals a long periodic splitting of the AF peaks, with a propagation vector τ=0.016Å^{-1}, induced by DM interactions. The scattering can be modeled qualitatively with an AF skyrmion-lattice like structure derived by superimposing the cycloidal modulation for each arm of the star of τ. The resulting structure exhibits a topological number of -1 allowing for the assumption of the compound featuring a skyrmion-lattice.

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Tuesday 05.07.16, 12:05

Anomalous thermal decoherence in a quantum magnet measured with neutron spin-echo spectroscopy

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The effect of temperature dependent asymmetric line broadening is investigated in Cu(NO3)2·2.5D2O, a model material for a 1-D bond alternating Heisenberg chain [1], and in the 3-D dimerized magnet $Sr_3Cr_2O_8$ [2], using the high resolution neutron-resonance spin-echo (NRSE) technique [3]. Inelastic neutron scattering experiments on dispersive excitations including phase sensitive measurements have been performed. Contrary to the usual way to model NRSE data, the polarization was fitted using a ray tracing simulation of the spectrometer, which tracks the spin phase of individual neutrons. The results demonstrate the potential of NRSE to resolve line shapes, which are non-Lorentzian, opening up a new and hitherto unexplored class of experiments for the NRSE method beyond standard linewidth measurements.

The second important finding is the non-linear evolution of the phase shift with temperature as a direct consequence of the non-linear line shapes. This leads to a breakdown of the powerful method to measure the renormalization of the excitation energy with a simple equation in the case of small renormalization changes. In this regards analysis beyond the conventional phase shift of a single spin-echo time is necessary. Furthermore, the phase carries important information about the line shape and should be included in the fit determining S(ω).

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Tuesday 05.07.16, 12:25

Emergent phases and frustration in model magnets

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Quantum magnets exhibit exotic ground states and novel elementary excitations, complex correlations and generic quantum critical points. Phenomena like frustration, condensation and quantum disorder are at the very heart of this field. More interestingly, novel emergent behavior can arise as a result of interplay between different characters of the same system.

As an example, we will present our combined polarized-neutron and resonant x-ray scattering studies on spin-orbital interplay in a Mott insulator [1]. Using similar techniques, we are further exploring new possibilities, including spin liquid and spin nematic phases. These can arise due to frustration in very simple model magnetic systems on square magnetic lattices [2, 3].

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Tuesday 05.07.16, 13:45

Complementary application of polarized neutron and resonant x-ray reflectometry to probe magnetic order in metallic multilayers

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Magnetic multilayers composed of alternating nanoscale magnetic and nonmagnetic layers are key elements of up-to-date spintronics. Modern growth techniques allow ones to obtain high quality multilayered systems and control their interface quality at atomic level. To go along with recent advances in growth techniques, the need for precise determination of in-depth magnetization distributions (at subnanometer scale) in such systems becomes more apparent. The most powerful techniques to probe magnetization depth profiles in multilayered nanostructures are polarized neutron reflectometry and resonant x-ray magnetic reflectometry.

The main advantage of polarized neutron reflectometry is its ability to directly probe atomic magnetic moments and provide information about the in-plane magnetic moment in absolute units. On the other hand, this technique is not element specific and, due to low incoming neutron beam flux, has limited spatial resolution. Resonant x-ray magnetic reflectometry provides both element sensitivity and high spatial resolution but it detects only the in-plane component of magnetic moment for the specific element within the scattering plane.

In our report we discuss strong points and weakness of both techniques and show that their complementary application allows one to gain high precision, depth-resolved, element-specific magnetization profiles in magnetically inhomogeneous superlattices. We stress that detailed depth-resolved magnetic information provided by this complementary approach cannot be obtained by applying any of these techniques separately. We illustrate how this complementary approach works in application to complex magnetic multilayered systems Fe/Gd and Fe/Cr/Gd.

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Tuesday 05.07.16, 14:10

Experimental evidence for FM/AFM interlayer exchange coupling from polarized neutron reflectometry and neutron diffraction

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An intrinsic property of antiferromagnetic (AFM) systems is the overall compensation of the atomic magnetic moments that prohibits the direct interaction of the spin-lattice with an external magnetic field. To overcome this limitation we have created artificial spin structures by heteroepitaxy between two bulk AFM $SrMnO_3$ (SMO) and $NdMnO_3$ (NMO). Thin superlattices with 1:2 ratio of SMO:$R$$MnO_3$ (*R*=Lanthanide) are known to exhibit ferromagnetism (FM) due to electronic reconstruction[1,2]. We demonstrate that charge transfer at the interface can be used to create thin FM layers adjacent to *A*-type AFM using thicker NMO layers as a magnetic *"handle"* to couple to the adjacent AFM spins.

We present polarized neutron reflectivity results that prove the FM order around the SMO layers. The coupling between FM and AFM is investigated with an interference based neutron diffraction technique that facilitates the long range correlations between neighboring NMO layers that is induced by the interlayer exchange coupling to SMO. We analyze the driving forces for the exchange with density functional theory, which reveals a FM interface coupling and quantifies the short range of the charge transfer.

These results confirm a layer-by-layer control of magnetic arrangements that constitutes a promising step towards magnetic control of AFM as necessary in spin-based heterostructures like multiferroic devices.

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Tuesday 05.07.16, 14:30

Chirality induced exchange bias effect in DyCo/FeNi bilayers investigated by polarized neutron reflectometry

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Alloys of rare-earth elements and 3d transition metals became recently again in the focus of attention due there rich variety of magnetic effects owed to the different anisotropies of both material classes [1-5].

In this work, a dual in-plane exchange bias effects (H_{EB}=±39mTesla) were found in the orthogonal coupled thin $Dy_{20}Co_{80}$/NiFe bilayer occurring at room temperature without the need of any field cooling procedure. Particularly interesting, the direction of the exchange bias effect can be switched by changing solely the direction of the perpendicular magnetic fields in relative moderate fields of about 200mT. The in-plane exchange bias keeps stable even at extern in-plane magnetic fields of more than 6T. The underlying mechanism behind the extraordinary effect was investigated with magnetic optical Kerr effect (MOKE), X-ray magnetic circular dichroism (XMCD) and polarized neutron reflectometry measurements (PNR). Particularly the use of polarized neutrons enabling one to get access to the chemical and magnetic depth profile was essential to identify chirality as the crucial mechanism behind the intriguing isothermal exchange bias effect. The application of polarization analysis allowed us to analyze the non-collinear magnetic structure during the switching behavior in detail. The exchange bias in NiFe can be attributed to the interface exchange coupling to the DyCo layer, while the exchange bias in DyCo layer is due to the formation of chirality in its spin structure formed during the deposition on NiFe. Latter indicates a Dyzaloshinskii-Moriya like term in the interacting energy originating from the broken inversion symmetry at the interface between both magnetic layers. Such chirality based exchange bias systems may be of crucial importance for the development of future applications in the field of magnetic sensors.

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Tuesday 05.07.16, 14:50

Sign-changing chirality in Ho/Y multilayers

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Previously, a net chirality in the spin helix structure of Ho/Y multilayers was found induced by an in-plane applied magnetic field during field cooling by polarized neutron reflectometry [1,2]. The average chirality is defined as a polarization-dependent part of the magnetic neutron scattering. Parameter γ, describing chiral symmetry breaking, increases unevenly when the sample is cooled below the Néel temperature T_N to a value of γ about 0.10. The chiral symmetry breaking occurs here at the paramagnetic – helicoidal phase transition.

In this work we study the chiral parameter depending on the orientation of the sample in an external magnetic field. The here discussed sample [Ho45Å/Y30Å] is grown by molecular beam epitaxy. It epitaxial formula is {1120}Al2O3‖{110}Nb‖{001}Y ‖{001}Ho/Y‖{001}Nb. The polarized neutron experiments were performed at the Super-ADAM reflectometer (ILL). The magnetic field was applied in the sample plane. The sample was rotated around the axis of the hcp structure in 15º steps in a total range of 180º. At each azimuthal orientation the sample was heated above T_N and cooled in a field H = 10 kOe to a temperature T = 60 K. The results of the experiment are presented in Fig. 1. The parameter γ shows alternating azimuth dependence with a period of about 180° on the orientation of the sample in the magnetic field. The finding indicated the existence of a uniaxial anisotropy of the film to explain the break of the chiral symmetry, which is not related to an absence of the inverse symmetry at interfaces.

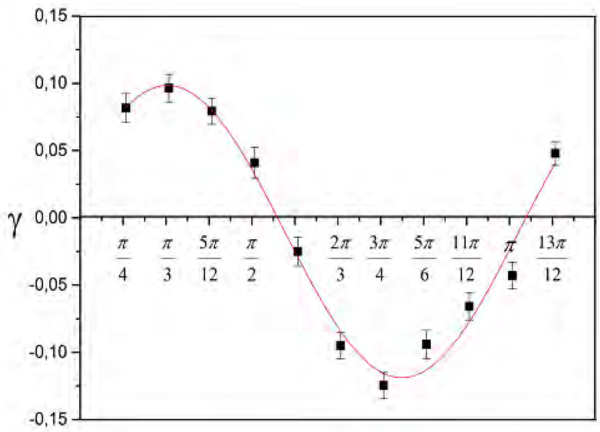

Fig.1. The dependence of the parameter γ on the orientation of the magnetic field in the basal plane.

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Tuesday 05.07.16, 15:10

Grazing incidence NSE with advanced optical components

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Grazing incidence neutron spin echo spectroscopy (GINSES) allows studying thermally induced slow motions of soft matter near a rigid interface. First experiments were carried out with a strongly scattering bicontinuous microemulsion [1,2]. Studying other soft matter systems, such as polymers or microgels [3] or phospholipid membranes in the vicinity of the interface [4] is highly interesting, but at the moment time demanding and difficult to do. The frontiers of the GINSES technique can be pushed forward with optical components such as resonator structures, increasing the intensity of the evanescent wave, or prisms [5], adapting the technique also to broad wavelength bands as it is encountered at spallation sources. First experiments with these advanced optical components are presented.

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Tuesday 05.07.16, 16:00

PNR from laterally patterned spin-valves

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Various types of spin-valves serve nowadays, as key elements in almost all contemporary computers and electronic gadgets. Their main function is to switch electric current via application of relatively weak magnetic field. This function is usually achieved in thin films with tri-layer structure consisting of one nonmagnetic layer, either metallic, or insulating, sandwiched between two metallic ferromagnetic layers. If one of the ferromagnetic layers is magnetically soft, while the other is hard then weak magnetic field can readily realign soft layer magnetization with respect to not affected magnetization in the hard counterpart. If conducting band electrons in ferromagnetic layers are highly spin-polarized then alternation of magnetization from a parallel to antiparallel configuration drastically changes conductivity and hence electric current through the tri-layer. Fast technological progress in commercial applications of various types of spin-valves is mostly achieved due to the deep understanding of fundamental aspects of the effect of giant (GMR), e.g. tunneling magnetoresistance (TMR). Such understanding results from extensive studies carried out during last decades with a number of experimental tools, including polarized neutron reflectometry (PNR) permitting to accomplish depth-resolved vector magnetometry (see reviews [1,2]). The scope of knowledge collected up to date, however, basically refers to continuous films, or isolated finite-size single spin-valve elements, although further perspectives in spintronics are associated with 2D (or even 3D) arrays of micro-, or nano-size spin-valve elements densely packed over a surface dramatically increasing information capacity. Here first results [3,4] on specular and off-specular PNR from lateral spin-valve arrays are reported. It is, in particular, demonstrated how a combination of specular PNR and off-specular Bragg diffraction can resolve not only layer-by-layer magnetization profiles, but also magnetization vector configurations within the surface of the spin-valve pattern, hence providing 3D magnetization distribution over the system.

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Tuesday 05.07.16, 16:25

Study of the in-plane magnetic structure of a layered system using polarized neutron off-specular and grazing-incidence small-angle scattering

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Layered magnetic structures exhibit interesting and important magnetic properties such as exchange coupling between layers, giant magnetoresistance, and tunnel magnetoresistance which are not present in the bulk. These anomalous magnetic properties basically arise from the structure in the out-of-plane and/or in-plane directions reduced to the nm range. The process of magnetization can be considered as an example of magnetic behavior which differs from the bulk case. When the grain size in a polycrystalline layer is comparable to or smaller than the ferromagnetic exchange length, the idea of formation and movement of domain walls fails to explain the measured results. Instead, the exchange interactions between neighboring spins become dominant over the local magnetocrystalline anisotropy of each grain. In order to verify whether this idea, known as the random anisotropy model [1,2], is valid in a layered system, it is important to obtain information on the in-plane magnetic structure during the process of magnetization.

In this study, the in-plane magnetic structure of Fe/Si multilayers with a polycrystalline grain size less than the ferromagnetic exchange length was investigated using polarized neutron off-specular scattering and grazing-incidence small-angle scattering measurements. These complementary measurements, each of them covering different length scales, together with the data analysis based on the distorted wave Born approximation, revealed lateral correlation in the fluctuating orientation of the magnetization in the layer on a sub-μm length scale [3]. The obtained in-plane magnetic structure is consistent with the random anisotropy model, i.e. competition between the exchange interactions between neighboring spins and the local magnetocrystalline anisotropy.

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Tuesday 05.07.16, 16:45

Fe Layer Induced Ferromagnetism in Pd: An *In-Situ* Polarised Neutron Reflectometry Study

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Magnetic data storage systems are based on thin magnetic layers and heterostructures. For improving the functionality of existing devices and to develop new ones, a deep understanding of the properties of these layers and the coupling between them is essential. In this context not only the classic room temperature ferromagnets are of interest but also elements which can be polarised, like Pd, in which induced magnetism is observed when it is brought into contact with Fe. To monitor the structural and magnetic properties during the deposition process, *in-situ* polarised neutron reflectometry (PNR) is used as a novel analysis technique. These PNR experiments were carried out at the neutron reflectometer AMOR at PSI (Switzerland) using the Selene focusing optics to reduce measurement times.

In this contribution the evolution of the magnetism in polycrystalline Pd/Fe/Pd thin film systems during growth will be presented. For as little as a single monolayer of Fe deposited onto an initial Pd layer a high induced magnetic moment of approximately $1\mu_B$ per unit cell was found in the Pd at the interface whereas the magnetic moment of the Fe is small compared to its bulk value. With more Pd deposited on top of the Fe layer, the magnetic moment of Fe increases while the induced magnetism in Pd decreases. An induced magnetisation of Pd was observed for a region of 7.5 Å on both sides of the Fe layer with a magnetic moment which decreases with increasing distance to the Fe/Pd interface. Additional TEM measurements show that the interfaces between Fe/Pd are sharp and it can be excluded that the magnetisation results from inter-diffusion or Fe clusters at the interface.

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Magnetic waveguides in polarized neutron reflectometry of oxide heterostructures

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The rich physics of complex oxide heterostructures (COH) is the intensive subject of theoretical and experimental study due to a big number of interface phenomena arising from reconstruction, strain, proximity effects etc. Magnetic ordering in COH features such phenomena as double exchange mechanism, strong electron-electron correlations and correlation of magnetic and transport properties that makes them attractive materials for developing of new functional devices.

Polarized Neutron Reflectometry (PNR) is one of the key techniques nowadays for studying magnetic properties of COHs. Since oxygen is the main scatterer in every layer of COH, nuclear contrast in the all-oxide heterostructures is small. This leads to the fact, that neutron reflectivities from magnetic oxide heterostructures are mainly sensitive to the magnetic contrast between neighboring layers, which is also pretty small. In order to enhance magnetic signal we propose special type of the neutron waveguide based on purely magnetic contrast. Compared to conventional nuclear-contrast waveguides magnetic contrast waveguides provides a very good depth selectivity of the different resonance modes. As experimental example, the magnetic state of Au(24nm)/LSMO(50nm)/SRO(50nm)//NGO was studied on neutron reflectometer NREX of research reactor FRM 2 (Munich). By covering the system with the layer of gold a waveguide structure is created where the first and second resonances are sensitive mainly to the LSMO and SRO layers, respectively. Using this approach we were able to detect a suppression of the 2nd waveguide peak at $T < 130K$ after field cooling. Such a suppression is interpreted as appearance of a small positive in-plane magnetic moment of only 0.34 μ_B/Ru in the SRO layer.

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Tuesday 05.07.16, 17:25

Growth and interfacial properties of FePt/Fe/NiO and FePt/NiO/Fe trilayers

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The exchange coupling effect between different phases of magnetic thin films has opened the possibilities to develop functional nanostructures for their potential use in magnetoelectronics and spintronics [1]. This effect emerges as exchange bias effect (when a ferromagnetic (FM) material is coupled with an antiferromagnetic (AFM) material) and as exchange spring effect (when a hard FM is coupled with a soft FM) [2, 3]. Moreover, different combinations of FM and AFM materials in the form of trilayers may allow the co-existence of (a) exchange spring and exchange bias effect together and (b) simultaneous in-plane and out of plane exchange bias. It is well known that exchange bias or exchange spring effects are interfacial phenomenon and are mainly driven by the interplay of magnetism at the interface. In this context, we have deposited epitaxial FePt(FM)/Fe(FM)/NiO(AFM) and FePt(FM)/NiO(AFM)/Fe(FM) trilayers using the molecular beam epitaxy (MBE) method and have studied its growth, structure and the interface magnetism.

In-situ reflection high energy electron diffraction (RHEED) patterns show that the growth morphologies of NiO/Fe and Fe/NiO on FePt are different and lead to epitaxial and textured growth respectively. In order to study the interfacial properties, ex-situ x-ray reflectivity (XRR) and polarised neutron reflectivity (PNR) have been performed. XRR and PNR results indicate that deposition of NiO-on-Fe forms a complex structure of Fe-O at the interface as a result exchange coupling is suppressed between Fe and NiO. On the other hand deposition of Fe-on-NiO results in reduced magnetic moment in Fe layer and significantly high spin flip reflectivity in PNR measurement. These observations may be attributed to strong exchange coupling at the Fe-on-NiO interface. The obtained results are very helpful in understanding the general behaviour of coupled metal FM and oxide AFM.

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Wednesday 06.07.16, 09:00

Polarized inelastic neutron scattering on Hybrid Spectrometer at SNS

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We report on the first results obtained using the polarization analysis on the Hybrid Spectrometer (HYSPEC) at the SNS. HYSPEC is the time of flight (TOF) spectrometrer, which utilizes reflection from the vertically focusing Heusler crystals array for polarizing the monochromatic incident beam, and a polarizing supermirror array with the 60 degrees horizontal acceptance for the polarization analysis of the scattered beam [1].

We present surveys of dynamical magnetic response probing the temperature-induced magnetic scattering in the parent iron chalcogenide $Fe_{1+y}Te$ [2], and in a nearly optimally doped superconductor material $FeTe_{0.55}Se_{0.45}$ using inelastic polarized neutron scattering. The measurements of spin-flip and non-spin-flip scattering were performed using the incident neutron energy E_i = 20meV and with the horizontal guide field aligned nearly parallel to the wave vector transfer, Q. With the flipping ratio of 14(1) when the sample is non-superconducting and 6(2) in the superconducting state below Tc we were able to independently map the temperature-dependent scattering in both channels and quantify its variation on cooling from 300K to 5K. The observed polarization-dependent magnetic response and its dependence of temperature provide important keys about involvement of magnetism in the development of superconductivity.

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Wednesday 06.07.16, 09:25

Magnetism of the triangular antiferromagnet $NiGa_2S_4$ and introduction of POLANO

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This talk consists of two parts; (1) Geometrical frustrated systems with reduced spatial dimensionality continue to challenge our understanding of condensed matter. Triangular lattice antiferromagnet, the simplest motif among the frustrated systems, is known to foster unusual magnetic properties. An example is magnetism of $NiGa_2S_4$ [1] where the correlation length associated with Ni spin-1 is pinned at an incommensurate period. Two anomalies in temperature dependence of spin fluctuation rate are not reflected in a gradual growth of spatial correlation, but indicate the formation of MHz spin fluctuation and subsequent quasi-static spin state [1]. Recent polarized neutron scattering experiment on MACS at NCNR shows directional changes of the spin fluctuations in its spin space. We show an overview of spatial/temporal spin correlations in $NiGa_2S_4$ as well as a quantum nature of the quasi-static spins, and discuss on potential origins including spin nematic scenario.

(2) POLANO, the polarized neutron spectrometer, is now under construction at J-PARC [2]. It aims to utilize high energy neutrons with spin-up/down analysis of the neutrons. For the polarization, a ^3He neutron spin filter will be equipped as the polarizer, and an array of supermirrors as the analyzer. We briefly present the progress and current status of the POLANO.

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Wednesday 06.07.16, 09:50

MARIA – The high-intensity polarized neutron reflectometer of JCNS

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The high-intensity reflectometer MARIA of JCNS is installed in the neutron guide hall of the FRM II reactor in Garching and is using a velocity selector, Fermi-Chopper combination for the monochromatization of the neutron beam (1%,3%,5% or 10%). The full cross section of the beam is polarized by a double-reflecting super mirror and in the vertical direction the elliptically focussing neutron guide increases the flux at the sample position and consequently reduces the required sample size or measuring time. A flexible Hexapod, as sample table, can be equipped with an electromagnet (up to 1.1T) or a cryomagnet (up to 5T), low temperature sample environment, a UHV-chamber (10^{-10} mbar range) for the measurement of Oxide MBE samples (transfer forth and back) and last but not least with various soft matter cells. Together with the 400 x 400 mm^2 position sensitive detector and a time-stable ^3He polarization analyser based on Spin-Exchange Optical Pumping (SEOP), the instrument is well equipped to investigate specular reflectivity and off-specular scattering from magnetic layered structures down to the monolayer regime. Furthermore the GISANS option can be used to investigate lateral correlations in the nm range. All the options, like GISANS, polarization and ^3He polarization analyser can be moved in and out of the beam in seconds by remote controlled push button operation and do not require any realignment.

MARIA is a state of the art reflectometer at a constant flux reactor. It gives you the opportunity to investigate easily reflectivity curves in a dynamic range of up to 7-8 orders of magnitude including off-specular scattering and GISANS measurement. Furthermore the high intensity allows for kinetic measurements down to a few seconds over a dynamic range of 3-4 orders.

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Wednesday 06.07.16, 10:10

Larmor: A flexible instrument for SANS, Polarised SANS and Larmor precession techniques

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The Larmor instrument has been operational since early 2015. It has been constructed as a polarised SANS instrument with a large, open blockhouse suitable for the convenient installation of Larmor precession equipment. The instrument is part of the continuing collaboration between ISIS and TU-Delft which enabled the development of the OffSpec reflectometer. As with the OffSpec instrument ISIS has provided the core SANS components and TU-Delft will provide a spin echo system that will be installed during autumn 2016. The initial commissioning and performance of the instrument and its polarising will be reviewed and compared with simulation. Further details of the ongoing user program and future developments will then be discussed.

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Wednesday 06.07.16, 10:35

Time-of-flight and monochromatic polarized neutron reflectometry on D17 at ILL

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We present recent upgrades of the polarized neutron reflectometer D17 at the Institut Laue-Langevin, Grenoble. Four modes of operation, time-of-flight and monochromatic, polarized and non-polarized, can be chosen from with minimal interference with the experimental configuration. This offers a data acquisition mode ideally suited for the experiment at hand, in areas of materials, soft-condensed matter, biology and magnetic studies.

We introduce a *coherent* data reduction procedure [1] allowing the use of fully divergent beams for optimized flux exploitation without resolution losses. The resulting gain enables measurements on sub-second time-scales. Similarly, non-flat samples, for example curved surfaces, can be analyzed with full flux and resolution recovery. The reduction procedure takes place in linear detector coordinates and can be directly implemented into existing procedures without the need for extra coordinate-transformations.

For polarized studies a monochromatic wavelength of λ = 5.5 Å ($\Delta\lambda/\lambda$ = 4%) is delivered at a take-off angle of 4° with a polarization exceeding 98%. Alternatively, in time-of-flight mode, a recently commissioned S-Bender polarizing supermirror (m = 3.2) provides a wavelength band of 4 – 20 Å with flat polarization above 99 % (2 - 27 Å un-polarized). Polarization analysis is performed either using a supermirror or a polarized ^{3}He-cell for off-specular scattering. Two radio-frequency spin-flippers with flat polarization efficiency of 99.5% for all wavelength provide access to all spin cross-sections.

A wide range of sample environment complements the suite of applications on D17, including cryogenic environments with large magnetic fields (7 T) in different directions. We will show experimental results highlighting the benefits of this advanced flexibility. The studies include magnetic gradients in thin film Heusler alloys and off-specular scattering from lateral magnetic domain patterns.

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Wednesday 06.07.16, 11:20

Q=0 Magnetic order in the pseudogap state of cuprates superconductors

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There has been a long-standing debate among condensed-matter physicists about the origin of the pseudo-gap state in high-temperature superconducting cuprates. Recent resonant ultra-sound measurements have provided evidence that the pseudo-gap phase is a symmetry breaking state, but the nature of the broken symmetry and the order parameter remain to be identified. Polarized neutron diffraction has revealed the existence of an ordered magnetic phase, hidden inside the pseudo-gap state of underdoped YBa2Cu3O6+x, HgBa2CuO4+d and Bi2Sr2CaCu2O8+d [1]. Interestingly, the ordering temperature Tmag matches the pseudo-gap temperature T* deduced from resistivity measurements. The magnetic order can be described as an Intra-Unit-cell magnetic order and it presents the symmetry predicted in the loop current theory of the pseudo-gap proposed by C.M. Varma [2]. In this theory, staggered current loops give rise to orbital-like magnetic moments within CuO2 unit cell. Recently, we have shown the persistence of the magnetic order close to optimal doping but with finite-size planar magnetic correlation lengths of about $\xi\sim$ 75 \AA [3]. Using the polarization analysis, we extract the moment components which display different temperature dependence.

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Wednesday 06.07.16, 11:45

Magnetostriction and magnetostructural domains in antiferromagnetic $YBa_2Cu_3O_6$

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We use high-resolution neutron Larmor diffraction and capacitative dilatometry to investigate spontaneous and forced magnetostriction in undoped, antiferromagnetic $YBa_2Cu_3O_{6.0}$, the parent compound of a prominent family of high-temperature superconductors. Upon cooling below the Néel temperature T_N = 420 K, Larmor diffraction reveals the formation of magnetostructural domains of characteristic size ∼240 nm. In the antiferromagnetic state, dilatometry reveals a minute (4×10^{-6}) orthorhombic distortion of the crystal lattice in external magnetic fields. We attribute these observations to exchange striction and spin-orbit coupling induced magnetostriction, respectively, and show that they have an important influence on the thermal and charge transport properties of undoped and lightly doped cuprates.

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Wednesday 06.07.16, 12:05

Magnetic structure of the noncentrosymmetric heavy-fermion superconductor CePt3Si

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The tetragonal heavy-fermion compound CePt3Si has attracted strong attention from both experimentalists and theoreticians in recent years because it shows unconventional superconductivity despite its noncentrosymmetric crystal structure. The lack of inversion symmetry leads to an antisymmetric spin-orbit coupling, which mixes spin-singlet and spin-triplet Cooper-pairing channels. This so-called Rashba-type spin-orbit coupling also leads to an anomalous dynamic spin susceptibility as revealed by polarized inelastic neutron scattering [1]. The superconducting transition occurs at Tc=0.75 K, well inside the magnetically ordered state that sets in at TN=2.2 K.

The magnetic structure is characterized by a propagation vector k=(0,0,1/2), and is supposed to consist of sheets of ferromagnetically ordered moments aligned in the a-b plane, the sheets being stacked antiferromagnetically along the c axis. However, the direction of the moments in the a-b plane is fully unknown. Also, the magnitude of the ordered moment, which is strongly reduced in zero magnetic field, has been reported to increase substantially with increasing magnetic field [2], which is a quite unusual and puzzling behavior.

We have redetermined the magnetic structure using elastic polarized neutron scattering with field-projected (longitudinal) XYZ polarization analysis on the IN20 triple-axis spectrometer, using a set-up with Heusler monochromator and analyzer and a Helmholtz coil at the sample position. Care was taken to minimize contributions of unpolarized higher-order neutrons from the monochromator. We find that the magnetic structure is different from what has been assumed hitherto. This has strong implications for the magnetic phase transition and the low-temperature structure of the system, and could provide a key explanation to the unusual magnetic field dependence of the ordered moment.

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Wednesday 06.07.16, 12:25

Magnetic moments induce strong phonon renormalization in FeSi

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The interactions of electronic, spin, and lattice degrees of freedom in solids result in complex phase diagrams, new emergent phenomena, and technical applications. While electron-phonon coupling is well understood, and interactions between spin and electronic excitations are intensely investigated, only little is known about the dynamic interactions between spin and lattice excitations. Noncentrosymmetric FeSi is known to undergo with increasing temperature a crossover from insulating to metallic behavior with concomitant magnetic fluctuations, and exhibits strongly temperature dependent phonon energies. Here we show by detailed inelastic neutron scattering measurements and ab-initio calculations that the phonon renormalization in FeSi is linked to its unconventional magnetic properties [1]. Electronic states mediating conventional electron-phonon coupling are only activated in the presence of strong magnetic fluctuations. Furthermore, phonons entailing strongly varying Fe-Fe distances are damped via dynamic coupling to the temperature-induced magnetic moments, highlighting FeSi as a material with direct spin-phonon coupling and multiple interaction paths.

[1] S. Krannich *et al.*, Nature Communications **6**, doi:10.1038/ncomms9961 (2015).

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Wednesday 06.07.16, 13:45

Polarized neutron developments and applications at the NIST Center for Neutron Research

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A ^{3}He neutron spin filter (NSF) program for polarized neutron scattering was launched a decade ago to enhance polarized neutron measurement capabilities at the NIST Center for Neutron Research as part of the NCNR Expansion Initiative. During the last decade, the number of polarized neutron instruments has significantly increased from 2 to 8, and is expected to expand to more than 10 in the near future. These advanced polarized neutron capabilities have now become a major part of US polarized neutron facilities. In the first part of the talk, we present an overview of developments of a wide variety of polarized neutron instrumentation, including small-angle neutron scattering instrument, the thermal triple-axis spectrometer, the magnetic diffuse reflectometer, and wide-angle polarization analysis at the NCNR [1]. In particular, we focus on high intensity wide-angle polarization analysis capability on MACS (Multi-Axis Crystal Spectrometer). The polarized beam apparatus on MACS consists of a cylindrical ^{3}He spin filter cell in a radio frequency-shielded solenoid to polarize the incident neutron beam and two three-sectioned, “banana”-shaped, wide-angle (up to 100 degrees) ^{3}He cells located on opposite sides of the beam to spin-analyze scattered neutrons [2]. With recent improvements, the polarized beam capability on MACS provides an increase in counting efficiency for polarized experiments by at least two orders of magnitude compared to the conventional cold triple-axis spectrometer SPINS at the NCNR. We describe the performance of the wide-angle polarization analysis capability in several recent experiments, including increased polarization storage times from reduced magnetic field gradients and the development of “horseshoe”-shaped cells that have several advantages over the three-sectioned cell. A single horseshoe cell can cover the entire 220-degree angular range with high spatial and angular uniformity in the transmission and analyzing power. In the second part of the talk, we present several examples of scientific opportunities that have been addressed by these polarized neutron capabilities.

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Wednesday 06.07.16, 14:10

Polarised Neutron Instrumentation and Scientific Experiments at ANSTO

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At the Australian Nuclear Science and Technology Organisation (ANSTO), polarisation analysis has previously been available on the reflectometer PLATYPUS for magnetic thin film and multilayer studies. The operation of a Metastable Optical Pumping (MEOP) based ^{3}He polarising station and associated equipment that were acquired from the Institut Laue Langevin and in part developed at ANSTO has now provided this capability for more instruments. We have now measured the magnetic structure of multiferroic single-crystals and giant-magnetocaloric powder samples on the WOMBAT diffractometer and the TAIPAN triple-axis spectrometer using polarized neutrons. We have also measured the polarization and location of magnon excitation in a multiferroic single-crystal on the TAIPAN triple-axis spectrometer. These capabilities are now available to users in the materials research community. Commissioning tests have been done for polarised off-specular scattering capability on PLATYPUS to study lateral magnetic surface structure. It will soon be followed by polarization analysis on the cold neutron chopper spectrometer PELICAN for magnetic excitation measurements and polarised SANS on QUOKKA for magnetic nanostructured material and hydrogen-rich material studies. This presentation will highlight the material sciences measurements done using this new capability and present some of our development highlights.

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Wednesday 06.07.16, 14:35

HYSPEC: 3D Polarization Analysis with a Polarizing Supermirror Array Analyzer at HYSPEC

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HYSPEC has already proven to be a very effective and versatile high-intensity, medium-resolution, cold to thermal direct geometry chopper spectrometer optimized for inelastic neutron scattering measurements of excitations in single-crystals, when using unpolarized neutrons. Now, HYSPEC has also been commissioned in its full 3D polarization analysis configuration, and used for both elastic and inelastic polarization analysis experiments. A Heusler focusing array polarizes the incident beam, and a Mezei flipper is used to flip the spin state of the incident neutron beam [1]. A new set of electromagnetic coils wrapped around the sample position establishes field up to 30 Gauss in any direction at the sample. Polarization analysis is achieved using an array of polarizing remanent supermirrors with an m=3 polarizer coating (FeCoV) on both sides. Designed and constructed at the Paul Scherrer Institut, the array has 960 supermirrors distributed over 60^o, matching HYSPEC's movable detector array coverage. A electromagnet charging station has successfully inverted the supermirror polarization and intermittent charges preserve its remanent field. Results of commissioning and some initial experiments will be reported.

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Wednesday 06.07.16, 14:55

Polarized ^{3}He neutron spin filter for PA studies at the JCNS

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Polarized ^{3}He neutron spin filters are an important technique for polarization, and analysis in neutron scattering experiments. Much work has been done towards long term stable apparatus to provide time-constant neutron analyzing efficiency. The baseline in-situ apparatus has evolved over time and is currently applied as part of the instrument on the magnetism reflectormeter with GiSANS, MARIA[1]. More in-situ ^{3}He polaririzers are in the design and prototyping stage for KWS1, KWS2 and TOPAS[2]. All polarizers incorporate mu-metal magnetic cavities, NMR polarization monitoring and flipping, VBG narrowed diode laser array bars for the optical pumping, and hybrid K-Rb ^{3}He spin filter cells. Work is also underway on PASTIS[3] with recent neutron test at Helmholtz Zentrum Berlin. We will discuss recent developments and current status of the program.

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Wednesday 06.07.16, 15:15

Polarization analysis on the LET direct geometry time-of-flight spectrometer

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The LET instrument at ISIS is a cold, direct geometry time-of-flight chopper spectrometer with π sr detector coverage. Due to this feature, it is currently most often used to map magnetic excitations in single crystal samples. In conjunction with the upcoming upgrade of the primary spectrometer, we plan to install polarization analysis on LET. The polarized beam will be produced using a tapered "double-V" cavity, and flipping achieved with a ramped Mezei-type device to make use of all the frames in the pulse. The field environment for the banana-shaped ^{3}He analyzer cell will consist of two pairs of Helmholtz coils. While this will forego performing full *xyz* polarization analysis, the reduced shadowing of the scattered beam will allow for use of most of the detector. Beyond magnetism, we expect that polarized LET will be particularly well suited to polarized quasi-elastic neutron scattering (PQENS), which has recently been shown [1] to a be a viable and powerful method to probe dynamics with isotopic sensitivity. Scientific problems expected to benefit from the application of PQENS include complex motions in polymer or ionic liquid samples, as well as diffusion in proton conductors.

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Wednesday 06.07.16, 16:05

The IN15 upgrade and first results

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NSE resolution is limited by the magnetic field homogeneity, which is dictated by the quality of the correction elements. While a lot of effort was invested in improving the correction coils at all NSE spectrometers, progress seems to be very limited. Instead of further tuning of the corrections we took a new direction by re-optimizing the shape of the main solenoids, to decrease the amount of correction needed. Our calculations show a possible gain of factor two, which means even keeping our present correction elements a factor two increase in field integral is realistic. Taking into account another factor two, which we could already use at short wavelengths, we are aiming at a four fold field integral increase. The goal of the IN15 upgrade is to stretch the boundaries of the Neutron Spin Echo technique by significantly improving stability and resolution, as well as achieving a much higher effective flux. This shall allow extending the useful q-range to probe smaller structures and increasing the useful Fourier times in the µs-range. The improvements in resolution and effective flux are foreseen to be achieved by minimizing field inhomogeneities by a novel design of the precession magnets and compensation elements.

While IN15 has already reached a demonstrative 1 µs fourier time with 27.5Å wavelength, with these improvements we expect to offer the same performance with ten times higher flux at 18Å. Commissioning of the upgraded instrument has been started and latest results will be presented.

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Wednesday 06.07.16, 16:30

Larmor neutron diffraction with one precession arm

Ad van WELL, Theo Rekveldt, Jeroen Plomp

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A new variant of Larmor neutron diffraction, applying only a single precession arm in the initial or scattered beam, is proposed [1]. In this geometry the Larmor labelling, including the polarizer and analyser and possible spin flippers, is completely performed in front or behind the sample. The great advantage, compared to the two-arm Larmor precession geometry, is the fact that magnetic samples, e.g. iron-containing materials, can now be investigated, because depolarization and the Larmor phase change of the beam polarization in the sample is no longer of importance for the diffraction analysis. This application has lower resolution than the double-arm precession geometry, but is still considerably better than conventional diffraction instruments. The differences will be discussed.

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Wednesday 06.07.16, 16:55

MIEZE Larmor Diffraction

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In this talk we will show how the MIEZE (Modulation of IntEnsity by Zero Effort) technique can be applied to elastic scattering from single crystalline samples to probe real-space correlations such as a distribution of lattice constants $\Delta d/d_0$ or sample mosaicity η_S.

For this new variant of Larmor diffraction, which we call MIEZE Larmor diffraction, it is necessary to tilt the RF spin flippers by an angle $\theta_1=-\theta$ and to tilt the detector by an angle $\theta_2=+\theta$ relative to the incident and the scattered neutron beam, where 2θ is the Bragg angle. By choosing the MIEZE condition for Larmor diffraction the total Larmor precession angle becomes independent of the crystal mosaic η_S to first order while being sensitive to $\Delta d/d_0$. Alternatively, with a different relation between the RF frequencies and the distances involved, an instrument configuration can be chosen which is sensitive to sample mosaicity. Employing a semi-classical ray-tracing model we will argue that in fact a single RF flipper is sufficient for MIEZE Larmor diffraction.

The method introduced here is an alternative to the Larmor diffraction configuration with only one precession field as recently proposed by Rekveldt [1]. However MIEZE Larmor diffraction avoids the necessity to collimate the beam to reduce divergence and works without a position sensitive detector.

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Wednesday 06.07.16, 17:15

J-NSE: recent scientific and instrumental developments

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The J-NSE neutron spin echo spectrometer faces now 10 years of successful user operation at the FRM II research reactor, Heinz Maier-Leibnitz Zentrum (MLZ). Using the spin precession of polarized neutrons in magnetic field it is possible to measure tiny velocity changes of the individual neutron during the scattering process and thus to observe relaxation processes on nanosecond time scale covering mesoscopic length scale accessible by small angle scattering technique. Along with conventional bulk measurements in transmission mode, possibility of varying the penetration depth under grazing incidence conditions give access to the dynamics of thin films and multilayers in the vicinity of a surface by means of recently established grazing incidence neutron spin echo spectroscopy (GINSES).

Main scientific highlights over the last decade include:

- Depth resolved dynamics at solid-liquid interfaces [1-3],
- Diverse soft matter systems like polymers in confinement [4]
- Dynamics of biological system, for example protein dynamics [5].

The above-mentioned scientific questions also triggered various instrumental developments such as successive change to the novel design of ”Pythagoras” type correction coils, new polarizer and modified neutron guide concept.

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Wednesday 06.07.16, 17:35

A framework for modeling polarized neutron scattering from NMR spin-modulated systems

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The potential for utilizing the scattering of polarized neutrons from nuclei whose spin has been modulated using nuclear magnetic resonance (NMR) has previously been considered by Buckingham [1]. That work broadly considered the overall feasibility and utility of such experiments with a potential aim, for example, of studying slow structural changes such as those that occur in biological macromolecules. Here, from first principles, we present an in-depth development of the differential scattering cross-sections that would arise in such measurements from a hypothetical target system containing nuclei with non-zero spins. In particular, we investigate the modulation of the polarized scattering cross-sections following the application of RF pulses that impart initial transverse rotations to selected sets of spin-1/2 nuclei. The long-term aim is to provide a foundational treatment of the scattering cross-section associated with enhancing scattering signals from selected nuclei, employing minimal chemical or isotopic alterations, so as to advance knowledge of macromolecular or liquid structure.

[1] A.D. Buckingham, Chem. Phys. Letts., **371**, 517 (2003).

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Thursday 06.07.16, 09:00

Toward a broad-band neutron polarizer with flipping-ratio of thousands

Alexander PETUKHOV, Valery NESVIZHEVSKY, Thierry BIGAULT,
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We propose a new type of solid polarizer based on reflection by super-mirror (SM) coating. In classical devices of this type the transmitting medium is single-crystal Si. The Fermi potential of Si is lower than that of the magnetic layers (Fe) in the SM for spin-down neutrons. This mismatch results in spin-independent total reflection for neutrons with low momentum transfer Q which strongly limits the useful wavelength band. To overcome this limitation, we propose to replace Si single-crystal by a medium with a Fermi potential higher than that for spin-down neutrons in the SM magnetic layers. For Fe/Si SM good candidates are single-crystal Sapphire and Quartz. The very first prototype polarizer based on this idea has been build and experimentally tested on the instrument PF1B for fundamental physics at ILL. The details of realization and results of experimental tests will be presented.

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Thursday 06.07.16, 09:25

In-Situ Polarised Neutron Reflectometry during Thin Film Growth

Wolfgang KREUZPAINTNER[1], Sina MAYR[1], Jingfan YE[1], Birgit WIEDEMANN[1], Amitesh PAUL[1], Thomas MAIROSER[2], Andreas. SCHMEHL[2], Alexander HERRNBERGER[2], Jochen STAHN[5], Jean-Francois MOULIN[4], Panagiotis KORELIS[5], Martin HAESE[4], Matthias POMM[4], Björgvin HJÖRVARSSON[6], Peter BÖNI[1], and Jochen MANNHART[3]

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Thin magnetic layers and heterostructures thereof are the basic building blocks of a large number of magneto-electronic devices. Their performance strongly relies on the magnetic properties of the layers they consist of. These are functions of the layers' morphology and microstructure and on the coupling between them. Since these parameters can change during the process of growth, it is important for the understanding and optimisation of magnetoelectronic devices to not only accurately monitor the structural but also the magnetic properties during the process of growth.

While the structural characterisation of thin films during growth by various techniques is common practice (as e.g. commonly done by RHEED/LEED, STM or synchrotron radiation), the *in-situ* measurement of the magnetic properties of films using (polarised) neutron reflectometry is a challenging task. Within a collaboration of TU München, University Augsburg and MPI Stuttgart, we operate a mobile sputtering facility for the growth and *in-situ* monitoring of magnetic multilayers, which can be installed at suitable neutron beamlines. In our contribution, the setup and first proof of principle polarised *in-situ* neutron reflectivity measurements on *in-situ* grown Fe/Cr carried out at the ToF reflectometer REFSANS at the FRM II neutron source and at the AMOR beamline at PSI will be presented. At the latter, use of the Selene neutron optical concept allows very fast polarised neutron reflectivity measurements to be performed within only 15min per spin direction.

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Thursday 06.07.16, 09:45

First neutron mirror spin flipper: experiment, perspectives

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Neutron spin optics (NSO) [1,2] based on quantum aspects of the neutron interaction with magnetically anisotropic layers signifies the transition in polarized neutron optics from 1D (spin selection, as in conventional polarizers and analyzers) to 3D (spin manipulation). It opens new possibilities for spin manipulations and may lead to numerous innovations in neutron techniques. Compactness of NSO devices in comparison with the existing spin manipulation options is one of the advantages that may be essential for development of alternative measurement schemes, esp. for the study of small samples. Therefore, the probing of the basic principles and elaboration of the basic elements for NSO, investigation of their performance is quite essential. The first neutron mirror spin flipper was produced on the basis of non-magnetic [NiMo(5.32 nm)/Ti(4.94 nm)]x20 multilayer coated with a Co 92 nm film. A method for measuring the flipping efficiency was developed. The flipping efficiency was found to be 0.978±0.001. Such neutron spin-flipping reflectors may also be used as spin /2-turners. Moreover, they can be used to combine monochromatization of a polarized beam with turning spins of the monochromatized neutrons. Spin-flipping reflectors are essential for designing innovative devices that polarize more than 50% (up to 100%) of non-polarized neutrons (‘hyperpolarizers’).

[1] N.K. Pleshanov, J. Phys.: Conf. Ser. **528,** 012023 (2014).

[2] N.K. Pleshanov, J. Surf. Investig.: X-ray Synchrotron Neutron Tech. **9,** 24 (2015).

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Thursday 06.07.16, 10:05

Progress in Parallel Polarisation Analysis

Mechthild ENDERLE[1], Alexander PETUKHOV[1], David JULLIEN[1], Bjorn FAK[1]

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Neutron spectroscopy with polarisation analysis is a fantastically powerful tool, albeit, one of the most time-consuming. In the thermal neutron range, the use of polarisation analysis for inelastic scattering has been restricted to the conventional triple axis technique with a single analyser and detector, where polarised cross sections are measured point by point. We will present recent test results from a device for parallel multi-angle polarisation analysis providing gapless 75 degree-coverage of scattering angle. The device allows to employ 3He-cells to polarise the incoming thermal beam and to analyse the polarisation state at multiple scattering angles in parallel. This marks an important milestone for both TAS-type spectrometers with multi-angle analysers (like FlatCone) and direct-geometry TOF-spectrometers (like PANTHER).

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Thursday 06.07.16, 11:00

Measurements with Polarised Neutrons in Neutron Beta Decay

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Neutron beta decay is an excellent system to study the charged weak interaction experimentally. The decay is precisely described by theory and unencumbered by nuclear structure effects. Observables are numerous correlation coefficients which e.g. relate the spin of the neutron and the momenta of the particles, spectra and the neutron lifetime. Most importantly, precision measurements in neutron beta decay are used to investigate the structure of the weak interaction and to derive the element V_{ud} of the Cabibbo-Kobayashi-Maskawa matrix. These investigations are complementary and competitive to measurements at the high energy frontier at colliders.

The most prominent correlation in neutron beta decay is the beta-asymmetry which relates the spin of the neutron and the momentum of the decay electron. For the planned future experiments, the polarisation of the neutron beam has to be known and controlled on the 10^{-4} level.

In this talk I will present recent results of the PERKEO III spectrometer on the beta asymmetry at the 10^{-3} level obtained at the ILL, Grenoble. I will introduce the new instrument PERC, which is currently under construction at the MLZ, Garching, by an international collaboration. PERC is designed to improve measurements of several correlation coefficients by an order of magnitude. I will present the concept of the instrument as well as its current status.

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Thursday 06.07.16, 11:25

Polarized neutron activities at the J-PARC Materials and Life Science Facility
- An Overview -

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An overview and status of the neutron science instrumentation at the Materials and Life Science Facility (MLF) of the Japan Proton Accelerator Research Complex (J-PARC) will be presented with the special emphasis on the utilization of polarized neutrons.

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Thursday 06.07.16, 11:50

The current status of facilities at China Advanced Research Reactor

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China Advanced Research Reactor (CARR) was built in China Institute of Atomic Energy (CIAE), located in the southwest of Beijing and about 37 kilometers away from the central city. As a multipurpose research reactor, its main applications include neutron scattering, neutron activation analysis, isotope production, silicon doping, fuel element test, fundamental nuclear physics and so on. Cooperating with the internal and international users in the first phase ten instruments complete construction and are under commissioning, which are High Resolution Powder Diffractometer, High Intensity Powder Diffractometer, Residual Stress Diffractometer, Texture Diffractometer, Four Circle Diffractometer, Reflectometer, Small Angle Neutron Scattering, two Thermal Triple Axis Spectrometers and Isotope Separator On-Line instrument . In the second phase 7 instruments were approved and are under construction now. Although the operation license was not issued, the reactor was permitted to do the testing run several times and some results were obtained during the instrument commissioning.

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Thursday 06.07.16, 12:10

Polarized neutron activities at the JCNS

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An overview of the status and developments of the polarized neutron scattering instrumentation at the JCNS will be presented.

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Thursday 06.07.16, 12:30

MAGiC: the polarized single crystal diffractometer at ESS

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MAGiC is a polarized Laue-TOF single diffractometer, proposed for the European Spallation Source, which will be specifically dedicated to the broad research field of magnetic correlations. The combination of the time-of-flight Laue technique with a large 2 sr detector and the intense long pulse of ESS yields a new efficiency for magnetic structure determination, allowing "x-ray sized" crystals and epitaxial films studies on a daily basis. The permanent use of polarization and availability of extreme sample environment (temperature, field and pressure) will open the instrument to the large magnetism community.

To cover the needs for both Bragg diffraction and diffuse scattering, MAGiC will make full use of the optimized peak fluxes of the thermal and cold ESS moderators. The possibility to choose between thermal or cold fluxes will ensures MAGiC high versatility, by using cold neutrons for high Q-resolution studies of complex magnetic structures and thermal neutrons to cover a high Q-space and correlate atomic positions with magnetic properties. Taking advantage of the latest development in neutron optics, MAGiC will present a highly polarized beam (<P>=98%) from 0.6 to 6A with a useful flux as high as $3x10^9$ n/s/cm² at sample position combined with polarization analysis for cold neutrons.

In this talk, we will present the science case supporting the instrument as well as an overview of the instrument design mainly supported by McStas simulations. Using virtual experiments, we will also present the MAGiC potential on cases representative of today's chanllenges such as the study of micro-crystals, small magnetic contributions in superconductors, short range correlations in spin-ice or spin-density in molecular magnets.

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Abstracts

Poster session 1

Monday, 04.07.2016, 17:55

Frustrated and disordered systems

I. Shishkin — Study of the «ice-rule» fulfilling in ferromagnetic inverse opals by SANS

Magnetic nanomaterials

N. Grigoryeva — Study of ordered ferromagnetic nanoparticles with different morphology by polarized neutron method

X. Sun — Magnetic properties and spin structure of MnO and FePt@MnO nanoparticles

N. Chubova — Determination of the enantiomorph excess (crystal handedness) in the rnpolycrystalline metallic samples of B20 structures

Multiferroic and chirality

E. Altynbaev — Hidden quantum phase transition in Mn1-xFexGe: evidence brought by small-angle neutron scattering

A. Sazonov — Magnetic structure and magnetic domain population in multiferroic Ba2CoGe2O7 by polarized neutron diffraction

Strongly correlated electron systems

Y. Khaydukov — Long-range interlayer coupling in CuNi/Nb superlattices revealed by Polarized Neutron Reflectometry and SQUID magnetometry

P. Zakalek — Emergent Single Magnetic State in Mixed Valence Manganite Heterostructures

Polarized neutron techniques and methods

W. Kreuzpaintner — Polarised Neutron Reflectometry Carried out at the Time-of-Flight neutron Reflectometer REFSANS Using a 3He Spin Filter

V. Matveev	The study of the possibility of using thin Ti and Co films to improve polarizing coatings of neutron optics
M. Seifert	Neutron depolarization imaging of the pressure dependence of HgCr2Se4
I. Takashi	Development of the polarized 3He neutron spin filter for POLANO at J-PARC
H. Thoma	Studies on modulation-enhanced polarized neutron diffraction
J. Ye	Experimental Setup for Investigation on Magnetic Thin Layers by in-situ Neutron Reflectometry
S. Schwesig	Novel type of polarisation analysis with the multianalyser at PUMA
E. Iashina	Spin-echo small-angle instrument for study the structure organization of the chromatin in biological cell
V. Sadilov	Sectoral collimation in SESANS with time-gradient magnetic field

Thin films and multilayers

S. Pütter	First (quasi) in-situ neutron reflectivity measurements on ultrathin magnetic films at MARIA
T. Veres	Roughness replication in neutron supermirrors and periodic multilayers
S. Kozhevnikov	Polarized neutron channeling for the investigations of weakly magnetic thin films
A. Steffen	Detection of unexpected precipitates in LSMO films via PNR and TEM

Imaging

K. Hiroi	Magnetic field imaging of a driving electric motor using polarized pulsed neutrons at J-PARC/MLF

Soft matter and biology

B. Nagy	Determining the Hydrated Structure of poly(HEMA-co-PEGMA) Films

Poster session 2

Tuesday, 05.07.2016, 17:45

Polarized neutron instrumentation

W. Chen	A test platform for polarized neutron instrumentation development
S. Watson	3He spin filter advancements at the NCNR
T. Krist	Polarizing neutron optics from Helmholtz-Zentrum Berlin
A. Feoktystov	Polarized neutrons and polarization analysis on KWS-1 small-angle neutron scattering instrument of JCNS
D. Merkel	Four-bounce neutron polarizer for reflectometry applications
K. Pavlov	Optimization of a polarizer device for SANS-2 instrument at PIK reactor
W. Schmidt	Polarization analysis on the new IN12
P. Konik	Neutron optics optimization for two polarized neutron reflectometers
N. Violini	T-REX: Time-of-flight Reciprocal space Explorer, the bispectral direct geometry chopper spectrometer at the ESS
T. Bigault	Dealing with parasitic reflections in polarising supermirror devices
H. Kira	Development and Demonstration Study of Polarized 3He Neutron Spin Analyzer for Small-Angle Polarized Neutron Scattering Instrument in J-PARC
V. Bodnarchuk	Monte Carlo simulations of SESANS experiments using time-gradient magnetic fields
R. Gainov	2V-based polarizer for cold neutron TOF spectrometer NEAT-II
S. Pasini	New superconducting solenoids with optimized field-integral homogeneity for the neutron spin-echo spectrometer at MLZ
I. Zobkalo	New POLDI – project of reincarnation of a polarized neutron diffractometer at the reactor PIK
K. Nemkowskiy	Recent developments at DNS, diffuse neutron scattering spectrometer with polarization analysis at MLZ
K. Nemkowskiy	Simulation and optimization of new focusing polarizing bender for diffuse neutron scattering spectrometer DNS@MLZ

V. Hutanu	Polarisation Investigator POLI – new single crystal polarised neutron diffractometer at MLZ
K. Zaw Lin	Investigation of multilayered magnetic nanostructure Fe/Co and a new version of the neutron polarization analysis
E. Babcock	Latest results of practical testing of PASTIS with a TOF beamline
E. Babcock	Data corrections for neutron polarization simplified using an in-situ polarized 3He neutron spin filter
J. Voigt	Polarization analysis for polychromatic chopper spectrometers
V. Syromyatnikov	New compact neutron supermirror transmission polarizer
V. Syromyatnikov	Multichannel supermirror analyzers of neutron polarization of fan type
D. Pushin	Polarized neutron interferometer beamline for material research at National Institute of Standards and Technology

Monday, 04.07.2016, 17:55 Poster Session 1

Study of the «ice-rule» fulfilling in ferromagnetic inverse opals by SANS

I.S. SHISHKIN[1], A.A. MISTONOV[1,2], N.A. GRIGORYEVA[2], S.V. GRIGORIEV[1,2], D. HONECKER[3]

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Inverse opal-like structures (IOLS) can be synthesized by filling the voids of opal templates with suitable structure-forming precursors and subsequent removal of the initial microspheres to leave three-dimensionally ordered porous materials. The inverse opals based on ferromagnetic metals (Ni, Co, etc.) are interesting as a three-dimensional nanoscale analogue of highly frustrated systems called spin-ice [1] and we speculate, that their magnetic properties can be described with exploiting «ice-rule» concept [2].

In order to investigate magnetic structure with the period of 750 nm under magnetic field, we performed small-angle polarized neutron scattering experiment on the D33 machine in Institute Laue-Langevin (ILL). A polarized neutron beam with a wavelength λ = 1.7 nm, and a bandwidth λ/λ = 0.1 was used. An external magnetic field H up to 1.5 T was applied along the beam direction. The sample was set such that the field was along the [111] axis. Then the sample was rotated by -35° around the vertical [$20\bar{2}$] axis to direct the field along the [101] axis. Finally the sample was rotated by +55° with respect to the initial position to direct the field along the [100] direction. For all three geometries we have registered the field-dependent diffraction patterns with two beam-polarization states (+P, -P) at room temperature. The pure magnetic contribution to the neutron scattering intensity was extracted by adding the data for the states with +P and –P, while the nuclear-magnetic interference contribution was extracted by subtracting the data for these states.

It is shown that the three experimental geometries represent three different types of the interplay between external magnetic field and the «ice-rule»: (i) when the magnetic field counteracts to the "ice-rule" arrangements of, (ii) when the magnetic field promotes to the "ice-rule" arrangements, and (iii) when the magnetic field is neutral to the "ice-rule" arrangements the magnetic moments in the structure.

[1] M. J. Harris, S. T. Bramwell et. al., Phys. Rev. Lett. 79, 2554 (1997).

[2] A.A. Mistonov et al., Phys. Rev. B, 87, 220408(R) (2013)

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Study of ordered ferromagnetic nanoparticles with different morphology by polarized neutron method

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Magnetic properties of spatially ordered interacting ferromagnetic nanoparticles, embedded into the diamagnetic template, have been studied by small–angle diffraction of polarized neutrons. The shape of these particles is octahedral, tetrahedral, cylindrical and needle-like. Their size is changed from a few to hundreds of nanometers. The spatial regularity (parameters of 2D and 3D structures) is given by template in which magnetic nanoparticles are formed. The interference (nuclear–magnetic) and pure magnetic contributions to the neutron scattering cross-section have been analyzed in the process of the magnetic reversal of the nanoparticles array in a field applied under the different angles to the 2D and 3D structures.

It is shown for 2D structures (spatially ordered cylinders, or needles) that the intensity of the magnetic contribution has hysteresis behavior in the magnetic reversal process that forms the field dependence of the intensity of a butterfly shape. A theory for describing the magnetic properties of the arrays of interacting ferromagnetic highly anisotropic nanoparticles in the magnetic field has been proposed. The nuclear-magnetic interference scattering must be analyzed with allowance for the two-fold (multiple) nuclear scattering process, which substantially distorts the interference observed under first-order Bragg reflection conditions. The corrected interference scattering curves provide the acceptable results consistent with the theory of polarized neutron scattering.

For 3D structures (face centered cubic structure of the octahedral and tetrahedral particles) it appears that direction of the local magnetization vectors of nanoparticles are rigidly directed along <111> crystallographic axes of the fcc structure, that allowed one to describe the magnetization reversal in terms of a phenomenological model, which takes into account the "ice-rule" for nanostructures.

The approaches used in our work make it possible to describe the collective magnetic behavior of systems, which consists of an ordered set of highly anisotropic nanoparticles or the isotropic nanoobjects, which are separate or connected to each other.

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Monday, 04.07.2016, 17:55 Poster Session 1

Magnetic properties and spin structure of MnO and FePt@MnO nanoparticles

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The spin structure of antiferromagnetic (AF) MnO nanoparticles (NPs) has been investigated for various diameters (5-20nm) using both magnetometry and polarized neutron scattering. Zero field cooled (ZFC) magnetization curves show a peculiar peak at low temperatures (ca. 25K) but no feature at the Neel temperature, T_N =118K. However, the AF order parameter of MnO shows the expected behavior from polarized neutron scattering studies. To resolve this apparent contradiction further magnetometry studies using ZFC/Field Cooled (FC) curves at various fields, memory effect and susceptibility measurements were employed. The results can be explained by a superposition of superparamagnetic-like thermal fluctuations of the AF Néel vector inside an AF core and a strong magnetic coupling to a Mn_2O_3 or Mn_3O_4 shell[1].

We have also studied the magnetic influence of ferromagnetic (FM) FePt particles in direct contact to MnO NPs. Neutron scattering results on the FePt@MnO dimer NPs show a comparable behavior to the MnO NPs. I.e. the AF order parameter vanishes at a temperature between 100 K and 140 K. However, an additional exchange bias is observed, which is explained by the exchange interaction of the MnO NP shell to the FePt subunit.

These results provide a closer insight into the spin structure and interactions of more complex NP configurations (i.e. dimers), which can possibly be used for novel nanomaterials with tailored physical properties or energy efficient nanomagnetic devices.

[1] X. Sun, A. Klapper, Y. Su, K. Nemkovski, A. Wildes, H. Bauer, O. Köhler, A. Schilmann, W. Tremel, O. Petracic, Th. Brückel, Phys. Rev. B (unpublished).

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Monday, 04.07.2016, 17:55 Poster Session 1

Determination of the enantiomorph excess (crystal handedness) in the polycrystalline metallic samples of B20 structures

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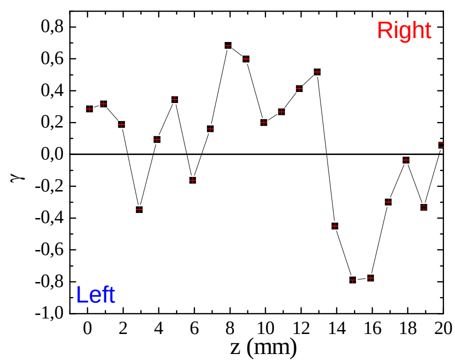
We investigate two series of large polycrystalline $Fe_{1-x}Co_xSi$ samples with x=0.1, 0.15, 0.20, 0.25, 0.30 and 0.50. The general aim of the experiment is to determine the average structural chirality Γ_c of these samples via spatially resolved measurements of the magnetic chirality using small angle scattering of polarized neutrons. We used the left-handed (first set) and right-handed (second set) seeds to grow single crystals by the Czochralski technique. Then, after the growth, we took the rest, which was left over in a crucible. After careful polishing the sample the number of crystallites in polycrystals was inspected using optical microscopy. The crystallites had a needle-like shape and an average volume of order 2 mm^3.

The small angle scattering of polarized neutrons was used to measure the magnetic chirality γ_m, which is directly coupled with the crystal handedness Γ_c as $\gamma_m = - \Gamma_c$ for the $Fe_{1-x}Co_xSi$ compounds with x<0.65 [1]. It is also known that the MnSi compounds show the left-handed helix in the left-handed crystallographic configuration $\gamma_m = \Gamma_c$ [2]. The γ-ratio for this sample is equal to 1 ±0.01 in the whole temperature range $T < T_C = 29$ K and under magnetic field $H < H_{C2} = 0.5$ T. Thus, the scattering maps from a MnSi single crystal taken at T = 25 K for neutron polarization parallel and antiparallel to the field **H**, were used to calibrate the experimental settings. The small-angle polarized neutron scattering (SANS) experiment was performed using the D22 instrument at the ILL (France). The measurements were carried out at T=5 K and the magnetic field of 0.01 T to align the helix wave vector in different crystallites toward the field axis. The samples have been scanned by the narrow neutron beam along the largest sample's axis. The typical example of the space-resolved scan of the spin chirality γ is shown in the Figure for $Fe_{0.85}Co_{0.15}Si$ compound. It varies strongly around 0 reaching in some cases, quite high values 0.6÷0.7. The positive and negative values of γ represent domination of one-hand chirality above the other-hand chirality. The statistical errors of the measured values γ do not exceed the small number of order of 0.01. The observed oscillations indicate the presence of large crystallites with a linear size of about 1-2 mm. The chirality averaged over the sample deviates from zero with an order of 0.1–0.2. The possible concentration dependence of the enantiomorph excess Γ_c in these compounds was not established for the reason of the lack of the statistics in the number of crystallites inside the polycrystalline sample.



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[1] S.-A. Siegfried, E. V. Altynbaev, N. M. Chubova, V. Dyadkin, D. Chernyshov, E. V. Moskvin, D. Menzel, A. Heinemann, A. Schreyer, and S. V. Grigoriev // Physical Review B, Vol. 91, Iss 18, pages 184406 (2015)
[2] S. V. Grigoriev and D. Chernyshov and V. A. Dyadkin and V. Dmitriev and S. V. Maleyev and E. V. Moskvin and D. Menzel and J. Schoenes and H. Eckerlebe // Physical Review Letters, Vol. 102, N 3, pages 037204 (2009)
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Monday, 04.07.2016, 17:55 Poster Session 1

Hidden quantum phase transition in $Mn_{1-x}Fe_xGe$: evidence brought by small-angle neutron scattering.

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The magnetic system of $Mn_{1-x}Fe_xGe$ B20-type solid solutions with $x < 0.4$ orders into helical structure with a wave vector $k \approx 2\ nm^{-1}$ at low temperatures [1, 2]. The value of the helix wave vector changes dramatically with further increase of concentration x to $k \approx 0.4\ nm^{-1}$ for $x = 0.5$ [1]. This change indicates the phase transition from the short period helical structure to the long period helical structure at a critical concentration $x_{C2} \approx 0.4$.

The temperature evolution of the magnetic structure of $Mn_{1-x}Fe_xGe$ with $x < 0.4$ was studied using small angle neutron scattering (SANS). The close inspection of the SANS patterns reveals the hidden quantum phase transition from the long-range ordered (LRO) to short range ordered (SRO) helical structure upon increase of Fe-concentration at $x_{C1} = 0.25$. The SRO is identified as a Lorentzian contribution, while LRO is associated with the Gaussian contribution into the scattering profile function. Further profile analysis have shown that the Gaussian contribution is resolution limited while the width of the Lorentzian contribution can be associated with the correlation length of the SRO phase. The quantum nature of the SRO of the helical structure is proved by the temperature independent correlation length at low and intermediate temperature ranges up to $T_Q \sim 60$ K for $x < 0.4$.

Thus we conclude that two quantum phase transitions of the magnetic structure of $Mn_{1-x}Fe_xGe$ appear with x increase. The Fe-replacement of Mn atoms in $Mn_{1-x}Fe_xGe$ firstly leads to the destabilization of the magnetic structure at $x_{C1} \approx 0.25$ and secondly to the phase transition from the short period to the long period helix at $x_{C2} \approx 0.4$. We suggest that both transitions are caused by the competition between the effective Ruderman-Kittel-Kasuya-Yosida interaction and Dzyaloshinskii-Moriya interaction, which are tuned by the changes in the electron and hole concentrations in $Mn_{1-x}Fe_xGe$.

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Monday, 04.07.2016, 17:55 Poster Session 1

Magnetic structure and magnetic domain population in multiferroic $Ba_2CoGe_2O_7$ by polarized neutron diffraction

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Emergence of ferroelectricity in several members of the melilite family, including $Ba_2CoGe_2O_7$, below their magnetic ordering temperature has been recently discovered [1,2]. The remarkable and complex response of these materials to magnetic and electric fields can be predicted by considering their magnetic symmetries [3,4]. In order to study experimentally the magnetic properties of $Ba_2CoGe_2O_7$ in the multiferroic state, we performed polarized neutron diffraction experiments.

Depends on the orientation of the antiferromagnetic component, the following types of magnetic space groups (MSGs) are possible in $Ba_2CoGe_2O_7$: $P2'_12_12'$ with moment along [100], $Cm'm2'$ along [110] or $P112'_1$ for a more general direction in the *ab* plane [3-6]. Moreover, small canting leading to the existence of the tiny spontaneous magnetization in the *ab* plane below $T_N \approx 6.7$ K is allowed according to the magnetic symmetry. In zero magnetic field, it is impossible to distinguish between those MSGs with conventional unpolarized neutron diffraction due to the presence of the symmetry-related energetically equivalent magnetic domains in each case.

In order to differentiate between the possible magnetic structures in $Ba_2CoGe_2O_7$, zero-field spherical neutron polarimetry (SNP) experiments were performed with a CRYOPAD on the polarized single-crystal diffractometers POLI (MLZ) and D3 (ILL). To study the influence of external field on the magnetic domain distribution the sample was cooled in the external field over the Néel temperature, the field was switched off and additional zero-field SNP measurements were done. The full polarization matrices were measured for dozens of Bragg reflections and treated within different magnetic models. It was found that even weak magnetic fields (20 mT) lead to a noticeable change of the ratio between the magnetic domain volumes. In contrast, applied electric fields (6 kV/mm) do not lead to the domain redistribution. The weak canting angle was also found in agreement with unpolarized neutron diffraction and bulk magnetization data. Thus, SNP sheds a new light on the complex properties of this multiferroic material.

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Monday, 04.07.2016, 17:55 Poster Session 1

Long-range interlayer coupling in CuNi/Nb superlattices revealed by Polarized Neutron Reflectometry and SQUID magnetometry

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We report results of a SQUID and Polarized Neutron Reflectometry (PNR) study on the interlayer coupling in $Cu_{30}Ni_{70}$/Nb superlattices. In contrast to Fe/Nb systems where an oscillating RKKY-like interaction was observed by PNR [1] we have found antiferromagnetic (AF) coupling of the CuNi ferromagnetic layers in a wide range of thicknesses of Nb-spacers from 1 nm to 15 nm. This AF coupling arises due to the competition of dipole-dipole interlayer exchange interaction and magneto-crystalline energy. By applying a magnetic field in-plane, the moments of neighboring CuNi layers gradually turn from antiparallel at remanence to parallel in saturation. Such a control of the magnetic state will allow us to fabricate superconductor-ferromagnet superlattices with long-range triplet correlations existing in the whole structure [2].

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Monday, 04.07.2016, 17:55 Poster Session 1

Emergent Single Magnetic State in Mixed Valence Manganite Heterostructures

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Strongly correlated electron systems, like ferromagnetic $La_{1/3}Sr_{2/3}MnO_3$ (LSMO) and $La_{1/3}Ca_{2/3}MnO_3$ (LCMO) with considerably different magnetic ordering temperatures (T_C^{LSMO} = 380 K [1] and T_C^{LCMO} = 260 K [2]), are promising materials for novel spintronic devices. The mechanism for magnetization in both materials is based on the superexchange [3] and double exchange interaction [4], leading to a possible mutual influence at interfaces between LSMO and LCMO layers.

Performed polarized neutron reflectometry measurements on LSMO/LCMO thin film heterostructures reveal a complex magnetic behavior, like an induced magnetic ordering in the LCMO layer due to the interface to LSMO. High above the Curie temperature of LCMO, the LSMO layers behave as free magnetic layers but in the proximity to T_C^{LCMO} these individual LSMO layers begin to couple. Finally, at the LCMO Curie temperature a single magnetic state emerges, which cannot be explained through electronic transport alone.

We will present the results of polarized neutron reflectometry measurements done on LSMO/LCMO multilayers.

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Monday, 04.07.2016, 17:55 Poster Session 1

Polarised Neutron Reflectometry Carried out at the Time-of-Flight neutron Reflectometer REFSANS Using a ^{3}He Spin Filter

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The use of a transportable ^{3}He-spin filter as broadband polariser for the Time-of-Flight neutron reflectometer REFSANS is presented. A novel characterisation method for ^{3}He-spin filters is proposed, which allows for an experimental simplicity. The data treatment procedure for extracting the spin-up and spin-down neutron reflectivity from measurements obtained for a time dependent ^{3}He polarisation, is shown and benchmarked by the extraction of a very weak magnetic signal from reflectivity data. The PNR data was measured on the magnetic heterostructure $Fe_{1nm}/Cu_{20nm}/Si_{substrate}$ in an externally applied magnetic field of 30 mT. It is compared to similar measurements on $Cu_{20nm}/Si_{substrate}$, which show no magnetic signal.

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Monday, 04.07.2016, 17:55 Poster Session 1

The study of the possibility of using thin Ti and Co films to improve polarizing coatings of neutron optics

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The reflection of neutrons from polarizing coatings is the most common method of producing beams of polarized neutrons. The structural imperfections such as non-magnetic regions at the interfaces and the oxide layer on the surface of the polarizing coating are now the main factors that reduce quality of polarizing CoFe/TiZr supermirrors [1, 2]. Using layers of definite thickness with a negative potential to suppress reflection of neutrons with the undesired spin from the potential barriers, one can significantly improve the quality of polarizing coatings, both mirrors and supermirrors [3]. Titanium and cobalt are the main candidates for materials of such "antibarrier" layers. This paper represents the results of the experimental study of the possibility of using thin Ti and Co layers in polarizing coatings.

To study the stability of thin metal layers in air, Ti and Co films with thickness 5-100 nm were deposited by magnetron sputtering on float glass. All samples was kept during several months in air at room temperatures. The parameters of metal and oxide layers were determined by neutron and X-ray reflectometry. Thinner Ti films were found to be oxidized to a greater depth; yet the metal layer was found to exist even in the thinnest (5 nm) samples [4, 5]. The thickness of native oxide layers on studied Co films does not depend on the thickness of initial metal Co layer. Some samples were annealed at a temperature T = 200°C to study the kinetics of the oxidation of thin Ti and Co films.

The next stage of our research was an expremental proof of suppression of reflection of neutrons with the undesired spin from the polarizing mirrors coated with Ti, Co and Co/Ti thin films. Measurements were carried out at the V6 instrument at Helmholtz-Zentrum Berlin and the reflectometer NR-4M at PNPI in Gatchina. The experimental results show a decrease in the reflection of spin-down neutrons from samples with antireflection metal/oxide bilayers in the q-region below 0.05 nm^{-1}.

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Monday, 04.07.2016, 17:55 Poster Session 1

Neutron depolarization imaging of the pressure dependence of HgCr2Se4

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The isostructural family of the Chromium spinels (ACr_2X_4) show diverse magnetic ground states due to an interesting variety of competing magnetic interactions between the chromium ions [1,2,3]. We report the magnetization of ferromagnetic mercury chromium spinel $HgCr_2Se_4$ up to 1.7 GPa. To extend these data we used high pressure neutron depolarization measurements, allowing us to quantify the evolution of ferromagnetic domains up to 4 GPa and down to very low temperatures. Surprisingly, the critical temperature displays a complex phase diagram pointing to a loss of ferromagnetism above 2.7 GPa. Our results demonstrate, on a proof of principle level, the feasibility of combining miniaturized moissanite anvil cells with neutron depolarization imaging. This paves the way for studies of ferromagnetic and superconducting phases up to very high pressures in a rather simple manner.

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Monday, 04.07.2016, 17:55 Poster Session 1

Development of the polarized ^{3}He neutron spin filter for POLANO at J-PARC

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POLANO is a newly constructed polarized inelastic neutron spectrometer at J-PARC [1]. It is designed to utilize high-energy polarized neutrons including the spin analysis of scattered neutrons. A ^{3}He neutron spin filter (NSF) is used for the incident beam polarization, and magnetic supermirrors for spin analysis. The latter will be replaced by another ^{3}He NSF to expand the neutron energy range in the near future. We present the development of a ^{3}He NSF for the incident beam polarization in POLANO.

The spin-exchange optical pumping (SEOP) method is employed to achieve a high and stable ^{3}He nuclear polarization in the instrument, namely *in-situ* SEOP. The ^{3}He NSF has to fit in a limited space of ~60 cm along the beamline and was designed as compact as possible while keeping the performance. A cylindrical ^{3}He cell with a diameter of 60 mm and a length of 60 – 100 mm covers the beam diameter of 50 mm at the ^{3}He NSF position. The cells were filled with ^{3}He gas at 2 – 3 atm or 12 – 30 atm-cm that is optimum to polarize neutrons with energies from 20 to 100 meV. A magnetically shielded solenoid inclusive of the neutron guide field was designed to produce a uniform magnetic field for the ^{3}He cell. An electrical film heater that does not interfere with the magnetic field of the solenoid was developed to keep the ^{3}He cell up to 300°C for hybrid SEOP [2]. Every component of the ^{3}He NSF system can be controlled remotely through LAN, including adiabatic fast passage spin flip of polarized ^{3}He nuclei as well as the polarization and the wavelength of laser light for optical pumping.

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Monday, 04.07.2016, 17:55 Poster Session 1

Studies on modulation-enhanced polarized neutron diffraction

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Modulation-enhanced diffraction [1] allows separating contributions independent and dependent of an external stimulation summed up in the diffracted intensity. For example by assuming an immediate, linear response of the active contribution to the external modulation, the measured intensity can be demodulated by a convolution and gives rise to additional information, which cannot extracted directly.

In the case of polarized neutron diffraction in a magnetic field, the measured intensity consists of nuclear and magnetic contributions among which only the magnetic part depends on the incoming neutron polarization. The diffracted intensity for a single Bragg reflection is thus a sum of a constant and an interference term, varying linear with the polarization. This reduces the demodulation process to a linear fit for the intensity over polarization. Therefore a precise knowledge of the polarization value is mandatory.

An experimental setup for modulation-enhanced polarized neutron diffraction (MEPND), using a new high Tc superconducting magnet and ^{3}He spin filter cells both as polarizer and analyzer, has been investigated. As modulation device for the neutron polarization, nutators used in spherical neutron polarimetry and alternatively classical Mezei spin-flipper were used.

Two MEPND data sets, namely on a nuclear Bragg reflection and a mixed magnetic-nuclear Bragg reflection in a test α-Fe_2O_3 sample, were measured. An analytic model for data reduction was developed to precisely determine the polarization. The refined polarization values were used as a modulation parameter for the measured Bragg peak intensity. Good agreement to the expected linear behavior for intensity vs. polarization dependence has been reached. The ratio between the nuclear and magnetic structure factor in the α-Fe_2O_3 test sample at certain magnetic field was calculated.

With these experiments, the feasibility of MEPND measurements on the diffractometer POLI [2] at MLZ was proved.

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Monday, 04.07.2016, 17:55 Poster Session 1

Experimental Setup for Investigation on Magnetic Thin Layers by *in-situ* Neutron Reflectometry

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Thin magnetic layers are used in many magneto-electronic devices. A thorough understanding of their texture and the coupling between them is, therefore, essential to improve functionality. In order to avoid the incorporation of impurities and surface contamination, these layers have to be grown under ultra-high-vacuum (UHV) conditions. An excellent method to analyze their structural and magnetic properties is polarized neutron reflectometry (PNR). Up to now, the sample growth and analysis have been performed in separate steps. The grown samples had to be removed from the vacuum after the growth process and put into the neutron beam line for analysis. This procedure is time consuming and leads to the sample being exposed to the environment which could alter their properties.

In this contribution, a compact in-situ vacuum sputtering chamber with integrated DC and RF sputtering equipment for performing in-situ neutron reflectometry experiments will be presented. It can be easily transported and installed at neutron beam lines and combines both, deposition and measurement, into one single setup. This allows magnetic properties of thin films as a function of their thickness and composition to be investigated, both, quickly and on one single sample, at different evolutionary deposition steps.

Despite the compactness of the device, no compromises regarding conditions for growth and measurement were made: A coil allows field dependent measurements and a cryostat with integrated heater can set the sample temperature in a range from 10K to 1000K. We constructed our device to be fully compatible to the REFSANS (FRM II) and the AMOR (PSI) ToF neutron reflectometers. At PSI, we can perform PNR measurements using the state-of-the-art SELENE neutron optical setup which reduces measurement times from hours to several minutes.

The results of very promising measurements on Fe/Pd, Fe/Cr and Fe/Cu layers are shown in contributions by Sina Mayr and Wolfgang Kreuzpaintner.

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Monday, 04.07.2016, 17:55 Poster Session 1

Novel type of polarisation analysis with the multianalyser at PUMA

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Polarisation analysis is one of the most time consuming methods in neutron scattering. Part of this is the need to spend time for measuring the spin-flip and the non-spin-flip channels. By combining the multianalyser system at PUMA with an innovative polarization analysis setup saves beam time by allowing a simultaneous detection of both channels.

A combination of two polarisers/deflectors reflecting spin-down and transmitting spin-up neutrons are used to differentiate the neutron beam scattered by the sample. The separated beam components reach different blades of the PUMA multianalyser where they are reflected towards different detectors.

First test experiments performed recently demonstrated that the spin-up and spin-down components can be measured according to our expectations. The Bragg scattering of neutrons polarized by a ^3He filter on the anti-ferromagnetic hematite (Fe_2O_3) sample was analyzed using the presented technique. In the case of nuclear reflex (006) only the transmitted (non-spin-flip) signal was recorded, whereas the anti-ferromagnetic scattering (003) shown both signals: transmitted (non-spin-flip) and reflected (spin-flip) signals. These two signals were clearly distinguishable with our setup and observed simultaneously in a single measurement.

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Monday, 04.07.2016, 17:55 Poster Session 1

Spin-echo small-angle instrument for study the structure organization of the chromatin in biological cell

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Spin-echo small-angle (SESANS) technique is a new efficient method to measure structures of materials in real space. The SESANS approach links the polarization P(z) of the neutron beam to the projection G(z) of the autocorrelation function γ(r) of the density distribution ρ(r) of the sample. The method is based on the Larmor precession of polarized neutrons transmitted across two precession devices before and after the sample, which encodes the scattering angle into a precession angle [1]. The polarization in a SESANS experiment is measured as a function of the total scattering cross section σ, the thickness of the sample l and the spin-echo length z

$$P(z) = \exp(l\sigma(G(z)-1)). \quad (1)$$

The spin-echo length z is the real-space distance over which correlations are measured in the sample [2]. The sample of isolated chicken erythrocyte nuclei was investigated at the SESANS-instrument at the HOR reactor of the Delft University of Technology, The Netherlands (Fig.1). In order to tune the value of the SESANS signal one can change the scattering cross section σ (dependent on wavelength λ and contrast (ρ_{sample}-$\rho_{solvent}$)) and the thickness of the sample l (Eq. 1). In present study we used the contrast-variation technique (D_2O 95%) and different thickness (2, 4 mm) to obtain the noticeable SESANS signal from the chromatin in the nucleus. We formulated the criteria necessary to perform the complete study of such biological objects using the SESANS method: (i) to have possibility to change the neutron wavelength; (ii) to use different thicknesses; (iii) to use the contrast-variation technique.

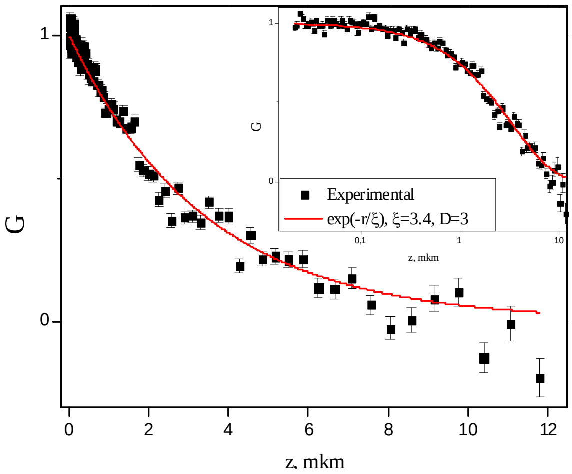

Fig.1 *SESANS function from isolated chicken erythrocyte nuclei.*

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Monday, 04.07.2016, 17:55 Poster Session 1

Sectoral collimation in SESANS with time-gradient magnetic field

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In the spin-echo small-angle neutron scattering method (SESANS) the scattering angle is encoded by phase of neutron spin Larmor precession, acquired when a neutron passes through the magnetic field area. For increasing the sensitivity to scattering angle, the boundaries of magnetic fields of spin rotators are tilted and form an acute angle with the direction of the beam. However, this method maximizes the angular resolution only for neutrons scattered in one preferred scattering plane - the plane of tilt of magnetic field. For neutrons scattered in other directions the angular resolution is reduced, that worsens the overall resolution.

To partially overcome this problem, we propose to use the sectoral collimation in the scattered beam. It is shown by VITESS simulations for sectoral and rectangular collimations in the SESANS with time-gradient magnetic fields, that the use of the sectoral collimators improves resolution and allows for a gain in the measurement time in spite of excluding a part of scattered neutrons.

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Monday, 04.07.2016, 17:55 Poster Session 1

First (quasi) in-situ neutron reflectivity measurements on ultrathin magnetic films at MARIA

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The magnetic neutron reflectometer with high incident angle (MARIA) at the Heinz Maier-Leibnitz Zentrum (MLZ) in Garching, Germany is a dedicated instrument for polarized neutron reflectometry of thin films [1]. However, due to limited space a UHV system for thin film growth and in-situ measurements cannot be placed on-site.

Recently, we have solved this problem by developing a handy mini UHV chamber which is capable for both, sample transfer and quasi in-situ measurements at the neutron reflectivity instrument, respectively. Quasi in-situ polarized neutron reflectivity (PNR) measurements can be performed at room temperature in magnetic fields of up to 600 mT. Our solution consists of a DN CF-40 cube with two opposing sapphire windows for the neutron beam, a combined non evaporable getter and ion pump for keeping the vacuum, a wobble stick, which is needed for in-situ sample transfer and also serves as sample holder for samples of up to 1 cm^2 and a valve for sample exchange by mounting the chamber on the MBE system. The pressure in the transfer chamber is kept in the 10^{-10} mbar range during transport and PNR measurement.

We present the first polarized neutron reflectivity measurements on a 2 nm Co thin film which was grown in our MBE setup and measured afterwards at MARIA at room temperature in a magnetic field of 300 mT in the Q-range up to 0.2 $Å^{-1}$. The data evaluation clearly shows no oxidation of the Co film. So, samples which are delicate to handle in ambient conditions can be successfully measured using our handy UHV chamber.

Booking of the access to the MBE system as well as the transport chamber for measuring is possible via the MLZ user office system and the nanoscience foundry and fine analysis project (NFFA, www.nffa.eu) in combination with an application for a beam time at the neutron instrument MARIA.

This project is part has received funding from the EU’s H2020 research and innovation programme under grant agreement n. 654360.

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Monday, 04.07.2016, 17:55 Poster Session 1

Roughness replication in neutron supermirrors and periodic multilayers

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Interface roughness strongly influences the reflectivity of neutron supermirrors (SM) the major components of neutron optical devices. The in-plane and out-of-plane correlation of the interface roughness was studied using neutron and X-ray off-specular reflectometry in DC-sputtered Ni-Ti and Fe-Si SMs and periodic multilayers. Roughness correlation is manifested in diffuse scatter plateaus and peaks which are interpreted in terms of Resonant Diffuse Scattering (RDS). A lower estimate of a few 1000 Å out-of-plane correlation length was found by off-set X-ray diffuse scans for periodic Ni-Ti multilayers of various bilayer thicknesses. Detector scans were carried out to observe off-specular neutron scattering from normal and reverse layer sequence SMs. The first order RDS is absent in normal but present in reverse sequence SMs, which is qualitatively explained by kinematical considerations. Distorted Wave Born Approximation simulations of off-specular scattering pattern both of normal and reverse SMs quantitatively reproduces the characteristic features of the measured curves with reasonable parameters, i.e. in-plane and out-of-plane correlation lengths and Hurst parameter.

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Monday, 04.07.2016, 17:55 Poster Session 1

Polarized neutron channeling for the investigations of weakly magnetic thin films

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We present and apply a new method to measure directly weak magnetization in thin films. The polarization of a neutron beam channeling through a thin film structure is measured after exiting the structure edge as a microbeam. We have applied the method to a tri-layer thin film structure acting as a planar waveguide for polarized neutrons. The middle guiding layer is a rare earth based ferrimagnetic material $TbCo_5$ with a low magnetization of about 20 mT. We demonstrate that the channeling method is more sensitive than the specular neutron reflection method. The results are published in our article [1].

[1] S.V. Kozhevnikov, Yu.N. Khaydukov, T. Keller, F. Ott, F. Radu, Pis'ma v ZhETF, **103,** 38 (2016). DOI: 10.7868/S0370274X16010070.

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Monday, 04.07.2016, 17:55 Poster Session 1

Detection of unexpected precipitates in LSMO films via PNR and TEM

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In thin film oxides, some properties can only be achieved via specific stacking of the individual atomic layers. To realize these structures, a precise growth control, often accomplished via feedback from in-situ Reflection High-Energy Electron Diffraction (RHEED), is needed [1].

20-25nm thin films based on $La_{2/3}Sr_{1/3}MnO_3$ (LSMO) were prepared via Oxide Molecular Beam Epitaxy (MBE) in fully shuttered mode. In-situ RHEED measurements exhibit distinct oscillations, indicating a stacking of layers with a stoichiometry controlled by the shutter opening times, in particular of the (La/Sr)O vs. MnO content. Further electron and X-ray scattering methods seemed to confirm the desired sample quality.

Data evaluation of Polarized Neutron Reflectometry (PNR) measurements showed a depth-dependent magnetic behavior not fitting the assumed stoichiometry profile. A combined refinement of XRR and PNR data requires increased Mn_xO_y content towards the surfaces in the model of the scattering length density. Additional HRTEM images revealed the existence of pure homogeneous perovskite LSMO layers with enclaved Mn_xO_y precipitates. Follow-up detailed SQUID measurements indicate these precipitates to have a Mn_3O_4 stoichiometry.

We identify the difference between nominal and actual layer composition indicating that LSMO prefers to grow in pure $La_{2/3}Sr_{1/3}MnO_3$ perovskite phase on $SrTiO_3$. The results clearly show that the common combination of methods leads to an incomplete picture of sample composition as the combination of PNR and TEM render a significantly different picture.

[1] J. H. Haeni *et al.*, Journal of Electroceramics **4**, 385 (2000)

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Monday, 04.07.2016, 17:55 Poster Session 1

Magnetic field imaging of a driving electric motor using polarized pulsed neutrons at J-PARC/MLF

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We have been developing a quantitative magnetic imaging method using the polarized pulsed neutron beam at the Materials and Life science experimental Facility (MLF) of J-PARC [1]. In this method, we analyze an oscillatory behavior in wavelength dependent neutron polarization due to the Larmor precession and evaluate magnetic field in a beam trajectory. Advantages of this technique are, at first, capability to obtain quantitative information about the magnetic field in a bulk material and a surrounding space, and large field of view up to several cm. According to these characteristics, this imaging technique is thought to be a promising method to observe a magnetic field in industrial products under driving states. In our previous work, we demonstrated visualization of ac magnetic field in a solenoid coil using polarized pulsed neutrons [2]. In this technique, we calculated the instantaneous magnetic field, which neutron experienced actually, by recording two kinds of timing information both time-of-flight and ac field, and successfully quantified the strength of the ac field for each phase.

One of the most interesting applications of this method is quantification and visualization of dynamic field in an electric motor, which is indispensable equipment in the industries. Because it consumes a lot of power, to clarify their actual magnetic field behavior in a driving state of it leads to the reduction of a power loss. In this study, we aimed to apply the ac field imaging technique to a driving electric motor and to clarify the relationship between the magnetic field of a motor and driving state of it. In advance, we performed numerical simulation of polarization distributions about the motor with its rotor at stable angles under several applied current conditions to the fixed stator. As the results, the polarization distribution was confirmed to depend on the composite magnetic fields of the stator and the rotor, and can be used to evaluate rotating state of the motor. Moreover it will be possible to evaluate deviation between the actual rotation of the motor and the ideal one by comparing experimental results with simulation. In the experiment, we measured temporal changes in the polarization distribution of the driving motor by means of the ac field imaging technique. In this presentation, we explain details of this ac field imaging technique and discuss about experimental results of driving electric motor.

We would like to appreciate Mr. Takao Imagawa of Hitachi, Ltd. providing the samples. This work was supported by Photon and Quantum Basic Research Coordinated Development Program from the Ministry of Education, Culture, Sports, Science and Technology, Japan.

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[2] K. Hiroi *et al.*, JPS Conf. Proc. **8**, 035001 (2015).

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Monday, 04.07.2016, 17:55 Poster Session 1

Determining the Hydrated Structure of poly(HEMA-*co*-PEGMA) Films

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Protein-resistant polymer coatings are of great research interest due to their use in biosensors, drug delivery and anti-fouling applications. Research has showed that the bound water molecules play an important role in determining the resistance properties [1]. Thus, the structure of these layers in wet state is greatly influenced not only by the covalent bonds of the monomers, but also by hydrogen-bonded water. Different polymerization procedures may result in different degrees of cross-linking in the film. Surface-initiated atom-transfer radical polymerization (SI-ATRP) has been shown to result in polymer brushes lacking cross-linking, while self-initiated photo grafting and photopolymerization (SI-PGP) produces polymers more prone to cross-linking.

2-Hydroxyethyl methacrylate (HEMA) and poly(ethylene glycol) methacrylate (PEGMA) are commonly used building blocks for polymers in anti-biofouling research. In this study, SI-ATRP and SI-PGP were used to prepare random poly(HEMA-*co*-PEGMA) copolymers, at a 1:1 ratio, since they have shown promising performance in fouling assays [2]. We have carried out biofouling assays using proteins and marine fouling organisms on these polymer films to investigate any differences in antifouling performance. To correlate these differences to structural properties of the polymers, we propose to use time-of-flight secondary ion mass spectrometry (ToF-SIMS), and polarized neutron reflectometry in conjunction with a magnetic reference layer, in order to further enhance the precision of the reflectometry experiments.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

A test platform for polarized neutron instrumentation development

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A multi-purpose test station, PHADES (Polarized ^{3}He And Detector Experiment Station) has been commissioned at the National Institute of Standards and Technology Center for Neutron Research (NCNR). The instrument is typically used for the testing of ^{3}He neutron spin filters (NSFs), polarized neutron devices, detector optimization, and crystal alignment, and is available for use for both internal and external users. Here we focus mainly on the development of ^{3}He NSFs and polarized neutron optics and techniques. We report some major activities, including characterization of wide variety of ^{3}He NSFs, test of an in-situ ^{3}He spin-exchange optical pumping system, polarized beam test with a superconducting magnet, and tests of various polarized neutron devices.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

^{3}He spin filter advancements at the ncnr

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As ^{3}He neutron spin filters (NSFs) continue to be used as an instrumental tool for the polarized neutron scattering community at the NCNR, development for current and new instruments has resulted in improvements in polarized neutronic performance, magnetostatic cavity improvements to increase achievable Q ranges, cell lifetimes, neutron spin transport, and minimization of ^{3}He polarization loss occurred during the adiabatic fast passage (AFP) NMR based ^{3}He polarization inversion. Instrument specific advancements include the development of a GE180 toroid cell for use on the Multi-Angle Crystal Spectrometer (MACS), an in-situ SEOP station for use on the Small Angle Neutron Scattering (SANS) instrument, and a new Polarized ^{3}He and Detector Experiment Station (PHADES) test beam line for NSF testing and development.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Polarizing neutron optics from Helmholtz-Zentrum Berlin

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In the last decades a variety of polarizing neutron optical devices has been developed at HZB, mainly solid state elements where the neutrons are transported in thin silicon wafers with coated walls, but also devices where the neutrons transmit silicon wafers with polarizing coatings. We show results of solid state polarising benders, solid state collimators with polarizing walls and a solid state radial bender for the polarisation analysis of neutrons over an angular range of 3.8 deg. Another device consists of a solid state polarising bender without absorbing layers used together with a collimator, which allows polarizing or analyzing neutrons without deflecting them from their original direction. Two-dimensional polarisation analysers for an angular range of 5 degrees in both directions are presented. A polarizing cavity in a guide with a cross section of 60mm x 100mm was built which polarizes neutrons with wavelengths above 2.5 Å. In all these polarizing devices polarisations of 95% were realised. In the last years several polarizing S-benders were build and tested. They had cross sections from 30 mm x 50 mm up to 60mm x 125mm. They were designed for different wavelength ranges, some as low as 2 Å to 6.5 Å. Typical values for the maximum transmission for the spin up component at a wavelength of 4.4Å are above 65% with a polarization above 98% [1].

[1] Th. Krist, F. Rucker, G. Brandl, R. Georgii: High performance, large cross section S-bender for neutron polarization, Nuclear Inst. and Methods in Physics Research A 698 (2013) 94-97.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Polarized neutrons and polarization analysis on KWS-1 small-angle neutron scattering instrument of JCNS

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The KWS-1 small-angle neutron scattering (SANS) instrument operated by the Jülich Centre for Neutron Science (JCNS) at the research reactor FRM II of the Heinz Maier-Leibnitz Zentrum in Garching near Munich has been recently upgraded [1].

Among the newly introduced instrumentation options the most important concerns polarized neutrons: KWS-1 has been equipped with a transmission supermirror polarizer and adiabatic radio-frequency spin flipper. The polarizer represents a three-channel V-cavity with Fe/Si coated supermirrors (m=3.6, SwissNeutronics AG; average polarization > 93%). In order to enable a robust switching between the polarized and unpolarized configuration, an automatic changer of revolver type has been designed and installed. The flipper was specially designed for a large beam cross-section; it fully encloses the neutron guide, so that there is no additional material in the beam. The flipper provides a high flipping efficiency of more than 99.9% for all neutron wavelength used on KWS-1 (4.7-20 Å).

The polarizer and radio-frequency spin flipper were characterized by means of a ^{3}He neutron spin filter installed at the sample position. The results and a comparison of test measurements on a ferrofluid in a magnetic field with polarized and nonpolarized neutrons are presented.

In order to further the study of magnetic systems a polarization analysis option is planned and in progress. A concept and results of the first tests of the polarized ^{3}He analyzer are presented.

[1] A. Feoktystov, H. Frielinghaus, Z. Di, *et al.*, J. Appl. Cryst., **48**, 61 (2015).

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Four-bounce neutron polarizer for reflectometry applications

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There are several concerns about polarizing a neutron beam. The polarization efficiency, the total transmittance, the acceptance, the beam deviation from the optical axis and the price of the actual device are all factors to be taken into account when the method of neutron polarization is chosen. Nuclear spin polarized ^{3}He spin filters, magnetic supermirrors, magnetic Bragg-reflection devices or magnetic planar waveguides have all advantages and disadvantages.

Here we present a 4-bounce reflection device which unifies wavelength filtering and spin polarization in a single device on a fix-λ neutron reflectometer. The successive four reflections of the neutrons from a homogenously magnetized supermirror sequence result in a highly (above 99%) polarized higher harmonic suppressed outgoing neutron beam, the direction of which coincides with the original optical axis. An identical device is used for spin analysis of specularly reflected neutrons on the GINA reflectometer at the Budapest Neutron Centre.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Optimization of a polarizer device for SANS-2 instrument at PIK reactor

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A small-angle neutron scattering instrument SANS-2 was transferred to PNPI from FRG-1 reactor in Helmholtz Centrum Geesthacht. At the moment the instrument is being reconstructed for being installed and operated at the PIK reactor in Gatchina. Among other parts, a new transmission polarizer for SANS-2 has to be developed. In this report, an overview of possible design of a polarizer for SANS machine is presented. A transmission bender, S-bender and V-cavity [1] were taken into consideration. The devices performance was simulated in McStas ray tracing package [2] using the input parameters for supermirrors of PNPI home production (CoFe/TiZr, $m = 2$). V-cavity seems to be the best choice for SANS-2. Two replaceable devices were optimized for providing beam polarization no less than 95% in the wavelength range of 4 to 25 Å.

The work was supported by Russian Federation Ministry of Education and Science (Federal target program, project №RFMEFI61614X0004).

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Polarization analysis on the new IN12

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IN12, a three-axis spectrometer for cold neutrons, is operated as a CRG-instrument from the Jülich Centre for Neutron Science (JCNS) at the Institute Laue Langevin in Grenoble. In the framework of the Millenium Program of the ILL IN12 has been relocated to a new position at the end of a new guide. Along with this relocation the whole primary spectrometer has been upgraded with new state-of-the-art components [1].

For the use of polarized neutrons a new transmission polarizer (cavity) has been installed in the neutron guide, mounted on a guide changer together with a standard guide element. This guarantees high intensities and an easy change from non-polarized to polarized mode.

Together with a new spin flipper and a focusing Heusler analyser IN12 presents state-of-the-art techniques for advanced polarized neutron experiments. Polarization analysis with high magnetic fields on the sample as well as a Cryopad set-up can be offered for measurements.

We will present details of the relevant neutron optical components and also show results from polarized experiments on the refurbished IN12 spectrometer.

[1] K. Schmalzl, W. Schmidt et al., Nuclear Instr. & Meth. A, **819,** p.89 (2016)

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Neutron optics optimization for two polarized neutron reflectometers

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The construction of high flux PIK reactor is finishing. In the framework of common PNPI-HZG project PIK-GGBase several neutron instruments were transferred from Geesthacht to Gatchina. Among them was NeRo – polarized neutron reflectometer. Simultaneously another neutron reactor IR-8 in Moscow is undergoing heavy modernization with installation of the new cold source. Three cold neutron instruments are proposed to be built including RPN – Reflectometer with Polarized Neutrons.

We have made a general study of optimization of optical system consisting of neutron guide and crystal monochromator. Elliptic and expanding guides were discussed and tested agains standart constant cross-section guide using Monte-Carlo simulations. Additional focusing guide between monochromator and sample is proposed which allows significantly increase flux at sample position.

Additional details on neutron guide design for both instruments are also described.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

T-REX: Time-of-flight Reciprocal space Explorer, the bispectral direct geometry chopper spectrometer at the ESS

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We present the concept of the bispectral direct geometry chopper spectrometer for the ESS neutron source. The instrument is designed to yield a dynamic range that extends from 20 µeV to 150 meV in energy transfer and from 0.01 $Å^{-1}$ to 17 $Å^{-1}$ in wavevector transfer. The elastic energy resolution (FWHM) can be freely adjusted in the range from 1% to 3% at 3meV and from 4% to 8% at 100 meV.

T-REX has been benchmarked against existing state-of-the-art neutron TOF-spectrometers and shows flux gain factors between one and two orders of magnitude and possible solutions are foreseen to increase the signal to noise ratio. These features make the instrument a real game changer in wide areas of scientific research: magnetism, strongly correlated electron materials, functional materials, soft-matter, biophysics and disordered systems. Independent of the specific application, it will allow parametric studies with acquisition times below one hour for a full data set from single crystals, the application of extreme conditions, in-situ or in-operando studies on timescales of seconds or spectroscopy from sub 100 mg single crystals.

It will implement time-of-flight spectroscopy with Polarization Analysis as a standard tool, e.g. for studying the effect of confinement on the magnetic excitations in nano-particles or to uniquely derive the vibrational hydrogen excitations in soft matter through separation of the nuclear spin incoherent scattering.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Dealing with parasitic reflections in polarising supermirror devices

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In most cases, when fabricating a neutron polarising device based on supermirrors (SM), parasitic reflections will degrade the performance.

In the case of a SM used in reflection geometry, parasitic reflections may happen at different places. The “unwanted” neutrons, whose spin state is opposite to the applied magnetic field, are transmitted through the SM. Depending on the backing medium, e.g. an absorbing medium with a higher optical potential than the non-magnetic material in the SM, some significant reflection of these neutrons may occur at low momentum transfer Q. This is particularly detrimental to the polarisation efficiency when trajectories with grazing incidence reflections (e.g. Garland-type) are possible in the device. An established solution to this problem is to use a backing multilayer stack which is both anti-reflecting and absorbing [1]. When penetrating into the SM from the “incident medium”, some reflection also occurs for the “unwanted” spin state neutrons at low Q if they experience a rising step in optical potential (e.g. from air to Fe/Si). A possible solution is to use a combination of incident medium and SM materials leading to a falling step in optical potential: e.g. air and Co/Ti, or sapphire and Fe/Si [2].

When the transmission geometry is used in a SM device, the neutrons transmitted through the coating go through a transparent substrate and generally encounter a second SM which has been coated on the back face in order to improve the polarisation efficiency. Some neutrons with the “unwanted” spin state (parallel to the applied field in this case), which are transmitted through the coating because of non-perfect reflectivity, will experience strong multiple reflections between the two faces. These reflections extend over the whole operating Q-range of the SM, and must be taken into account in order to estimate properly the device performance.

Some examples where parasitic reflections are encountered will be given for both reflection and transmission case, in connection with projects involving the fabrication of multilayer devices at the ILL: guide cavities, benders with air channels or with solid-state channels.

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Development and Demonstration Study of Polarized ^{3}He Neutron Spin Analyzer for Small-Angle Polarized Neutron Scattering Instrument in J-PARC

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Polarized neutron scattering techniques are very important and powerful tools to study the hydrogen-containing materials, because spin-incoherent scattering can be separated from nuclear-coherent scattering using the spin analysis technique [1]. Before, we performed a demonstrative SANS experiment using silver behenate at BL15 TAIKAN in J-PARC MLF [2]._The nuclear-coherent and spin-incoherent scattering components were successfully separated from the spin-flip and spin non-flip scattering using the in-situ spin exchange optical pumping (SEOP) based-polarized ^{3}He neutron spin filter (NSF) as an analyzer. Although the demonstration experiments were successful, the coverage area of the in-situ SEOP ^{3}He NSF was inadequate. We must heat the ^{3}He cell during the optical pumping process to vaporize the alkali metal, so the ^{3}He NSF was placed 120 mm behind the sample. The distance between the sample and the NSF limits the coverage area, so neutrons reaching part of the small-angle detector bank were spin analyzed.

In this work, we performed a demonstrative SANS experiment using an offline SEOP based ^{3}He NSF in order to overcome the limitation in the coverage area. Because we do not need to heat the ^{3}He cell during measurements, the offline SEOP ^{3}He NSF could be placed just behind the sample and could cover the full small-angle detector bank of the TAIKAN. It was confirmed that the offline SEOP ^{3}He NSF expand the variable scattering angle, reduced measurement time, and improved data quality.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Monte Carlo simulations of SESANS experiments using time-gradient magnetic fields

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The realization of a wide and different type of experimental possibilities at IBR-2 reactor in Dubna is a scientific priority of the Frank Laboratory of Neutron Physics.

At present, there is only one small-angle neutron scattering (SANS) instrument, YuMO operating at the IBR-2 pulsed reactor. The Q-resolution of this instrument is limited by $7\text{x}10^{-3}$, that doesn't allow the studies of large-scale structures and limits experimental possibilities suggested for users. This fact makes necessary the construction of a new high-resolution SANS instrument.

Here we are considering new opportunities which are opened by the development and implementation of a new Spin-Echo SANS method based on the use of time-gradient magnetic fields (TGF NSE), that matches well to the pulsed neutron structure of IBR-2. The time-gradient magnetic fields are realized as a periodic sequence of the saw-teeth-like magnetic pulses that are synchronized with the reactor pulses.

A virtual SESANS instrument with TGF for the IBR-2 pulsed reactor was assembled using the VITESS software package for the Monte Carlo simulations. The different operation modes of SESANS experiments, which are defined by the relation between the passing time of the neutron through the SESANS setup and the TGF pulse period, are revealed. In such approach, the real-space correlation function can be measured in a wide-range of spin-echo lengths. The experimental possibilities of the SESANS with TGF are demonstrated.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

2V-based polarizer for cold neutron TOF spectrometer NEAT-II

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The TOF spectrometer NEAT at the BER-II in Berlin is undergoing large scale upgrade to achieve 40 fold intensity gain. The new instrument will offer a number of new instrument and sample environment capabilities for optimized and efficient studies in area of magnetism, material science and soft matter (biological matter). Development and implementation of polarized neutron spectroscopy is an important part of the project.

In this study we present design concept of the polarizing neutron guide (polarizer) which is supposed to be installed at NEAT for the polarization of incoming neutrons. For the concept development several instrumental requirements and restrictions have been considered. The focused guide system should be optimized for the incoming neutrons with divergence, corresponding to m=3.0, and wavelength range of 3-10 Å, while the length of polarizer was set to 3.7 m. The intended polarization was set as 95 % and higher.

In the process of the concept development systems of parallel V-shaped supermirror cavities ("V-cavity") and two V-shaped cavities ("2V-cavity") have been considered. Analytical calculations have been performed to determine the performance of polarizing guides. It has been found that the 'hybrid" system, which polarizes and compresses the neutron beam simultaneously, is a preferable solution based on the initial focusing requirements. The basic model of hybride system was presented in [1]. Calculations show that the polarization provided by this model around 95-98 % within 3-8 Å is possible in case of construction with 3 V-shaped cavities in the first stage and 2 V shaped cavities in the second stage within the hybrid system. On the other hand, the derivative model, which is presented in this report, could provide nearly the same polarization (95 %) within the reduced wavelength range of 3.5-7 Å. The derivative model is differed from the basic due to reduction of two polarizing supermirrors (leading to decrease of total cost of polarizer) and changes of coating of other supermirrors.

This work is supported German Federal Ministry of Education and Research (project BMBF-05K12CB1). GR thanks Th.Krist, K.Leutenant and A.Ioffe for help in the beginning stage of calculations.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

New superconducting solenoids with optimized field-integral homogeneity for the neutron spin-echo spectrometer at MLZ

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For the upgrade of the neutron spin-echo spectrometer at MLZ (J-NSE) a new set of superconducting coils is being manufactured that will enhance the resolution of the spectrometer by reaching higher Fourier times. The new coils have been designed aiming at optimized magnetic fields with minimal intrinsic field-integral inhomogeneity and compensated stray-fields, for a wide and diverging neutron beam. The lower intrinsic field inhomogeneity in the beam area will minimize the amount of required correction, which is currently difficult to improve with the existing Fresnel coils due to technical limitations. We developed a semi-analytical approach [1] to calculate the optimum shape of the magnetic field that minimizes the field-integral inhomogeneities and, based on these results, a pair of superconducting coils with compensated net dipole moment has been commissioned to Babcock Noel, that will replace the currently used cylindrical copper coils. The new design will reduce the necessary corrector strength by over a factor 2 compared to present cylindrical coil designs and will provide field integrals up to 1.2 Tm.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

New POLDI – project of reincarnation of a polarized neutron diffractometer at the reactor PIK

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The project of considerable modernization of polarized neutron diffractometer POLDI presented.

Initially diffractometer POLDI was designed for the studies of the ferromagnetic domain structures and ferromagnetic correlations on the low-flux reactors. POLDI was operated during some years at 1MW PTB reactor initially and then on 5MW FRG-1 reactor at GKSS. After its shut down it was delivered to PNPI (Gatchina), where it is supposed to install at new high-flux reactor PIK.

Since we expect to have high intensity of polarized neutron, it is natural to adopt POLDI to the broader range of magnetic investigations such as determination of magnetic structures, detailed investigation of the complex magnetic structures, studies of magnetic domains, study of the magnetization density maps, magnetic form-factor particularities, local susceptibility, etc.

For the implementation of these features the flexible construction of some stages is considered, which permit to use either spherical neutron polarimetry technique which could be implemented with zero-field device like CryoPAD, or flipping ratio technique with 10T cryomagnet. In latter case the point detector will be replaced by 2D position sensitive one, which would provide neutron access with vertical opening +25º/-5º.

The essential part of the polarized diffractometer are polarizer and analyzer units. We propose to use for modernized polarizing benders as polarizer and analyzer as well. For the analyzer unit we consider to utilize focusing fan-like bender. Our stimulations give evidence that for interesting for us wavelength range (~1.3Å) and with suitable size, such device can give much better efficiency than ^{3}He cells, which are in use often. According to our calculation, the higher flux at the sample position, with factor of at least 2.5, with lower divergence and good polarization degree from 98% (1.3 Å) to above 93% (3 Å) makes the bender set-up favorable over the layout with the ^{3}He-cell. This is only direct gain. It should be emphasized also that bender acts as $\lambda/2$ filter which gives one more benefit.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Recent developments at DNS, diffuse neutron scattering spectrometer with polarization analysis at MLZ

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DNS is a versatile diffuse scattering instrument with polarization analysis operated by JCNS at the Heinz Maier-Leibnitz Zentrum (MLZ). A compact design, a large double-focusing PG monochromator and a highly efficient supermirror-based polarizer provide a polarized neutron flux of about 10^7 n/cm^{2}s. DNS is used for the studies of highly frustrated spin systems, strongly correlated electrons, emergent functional materials and soft condensed matter.

Here we present the recent developments and scientific highlights at DNS as well as the ongoing instrument upgrades. In the frame of this project, the neutron guide with m=1.2 has been replaced by the new one with m=2. Respectively, the flux for the short-wavelength range has been considerably enhanced. The available short wavelength range has been extended from 2.4 Å to 1.5 Å, with an accessible Q-range up to 7.8 Å^{-1} instead of 4.8 Å^{-1}. In order to deal with the increased neutron flux, the monochromator shielding has been replaced and improved. In addition, a neutron velocity selector has been installed and successfully commissioned. It allows us to suppress the high-order contamination of the monochromatized beam. Alternatively, the velocity selector can be used for selecting a shorter wavelength by the PG004 reflection with better resolution and without moving the secondary spectrometer. An important step toward a user-friendly instrument has been achieved by switching to the new generation instrument control software TANGO and NICOS. The new option for the data reduction and visualization in diffraction mode has been developed and implemented based on the Mantid project.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Simulation and optimization of new focusing polarizing bender for diffuse neutron scattering spectrometer DNS@MLZ

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DNS is a versatile diffuse scattering instrument with polarization analysis operated by JCNS at the Heinz Maier-Leibnitz Zentrum (MLZ) [1]. It is used for the studies of highly frustrated spin systems, strongly correlated electrons, emergent functional materials and soft condensed matter. During last years the instrument has been considerably upgraded; here the concept and the results of simulations for a new polarizer are presented.

The concept of the polarizer is based on the idea of the solid state bender made from the stack of the silicon wafers with double-side supermirror polarizing coating and absorbing spacers in between [2]. Owing to its compact design, such a system provides more free space for the arrangement of other instrument components. To reduce the activation of the polarizer we plan to use the Fe/Si coating instead of currently used FeCoV/Ti:N one.

As the polarizer at DNS is positioned after the double-focusing crystal monochromator, it is expected to accept a high divergence of the incoming neutron beam. Using VITESS package [3] we have performed the simulations for horizontally focusing polarizing bender in combination with the double-focusing monochromator. Neutron transmission, polarization efficiency as well as the effect of the focusing for a conventional convergent bender and S-bender have been analyzed both for wedge-like and plane-parallel convergent geometries of the channels. The results of the simulations and advantages/disadvanteges of various configurations are discussed.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Polarisation Investigator POLI – new single crystal polarised neutron diffractometer at MLZ

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Started as a polarised option for the single crystal diffractometer HEiDi at MLZ [1], POLI is grown up in last years and become recently an independent neutron scattering instrument with dedicated beam line in the front of the hot source of FRM II reactor [2]. In opposite to the other short wavelength polarised diffractometers which use Heussler alloy monochromator both to polarise and to select the required neutron wavelength, on POLI unpolarised variably focused monochromators in combination with dedicated polarisers are implemented. This allows both polarised and non-polarised diffraction studies on the same sample in the same condition to be performed at different wavelength. A number of discrete wavelength values from hot 0.29 Å to near thermal neutrons 1.15 Å are available using Cu (220) and Si (311) monochromators on POLI. ^{3}He spin filter cells are employed both to produce and to analyze neutron polarisation. This polarisation technique is especially advantageous for the hot neutrons. For the thermal part of the spectrum a dedicated supermirror polarising bender is under construction and will be implemented soon.

POLI is very versatile and flexible instrument which offers different measuring techniques. Three single-crystal diffraction methods are implemented yet or will be adopted soon on POLI. Namely, (1) zero-field spherical neutron polarimetry using third generation cryopad, (2) flipping-ratio measurements using high magnetic field, and (3) classical single crystal neutron diffraction on heavy or bulky sample environments like magnets, very low/high temperatures, pressure cells etc. Rather intense hot neutron flux makes POLI attractive also for the experiments in nuclear physics or medical research.

In this report we will show the design of the whole instrument with the emphasis on the polarisation components and present some examples of its application in resolving different challenging aspects in crystal, magnetic and domain structure of complex magnetic materials.

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Investigation of multilayered magnetic nanostructure Fe/Co and a new version of the neutron polarization analysis

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Interest in magnetic multilayered nanostructures doesn’t weaken for the last decades. In particular, it is caused by use of such structures as neutron optical elements in research neutron physical facilities [1]. In this work present the results of researches of magnetic multilayered periodic Fe/Co nanostructure by method of a polarized neutron reflectometry. Measurements are taken on the neutron reflectometer NR-4M at the WWR-M reactor (PNPI NRC “Kurchatov Institute”) by the TOF method [2]. Experimental and theoretical coefficients of reflection of a neutron beam from the multilayer magnetic Fe/Co nanostructure depending on the momentum transfer for several amount of a magnetic field and for both spin component are specified in work. It is established and confirmed with calculation that coefficients of reflection of the first order Bragg’s peaks for the researched Fe/Co nanostructure for both spin component of neutron beam are almost equal each other and weakly depend on a magnetic field.

In this paper we offer application of multilayer magnetic nanostructure Fe/Co as a bipolar monochromator-polarizer for the time of flight neutron reflectometer. In the work we introduce the new version of the neutron polarizing analysis by using the researched multilayered nanostructure on the basis of Fe/Co pairs. The new version of the neutron polarizing analysis have been compared with the traditional method of the neutron polarizing analysis as well.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Latest results of practical testing of PASTIS with a TOF beamline

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A complete XYZ polarization analysis solution is under development for the new thermal time of flight spectrometer TOPAS [1], to be operated in the new East neutron guide hall at the FRM II. Polarization Analysis Studies on a Thermal Inelastic Spectrometer, commonly called PASTIS [2], is based on polarized ^{3}He neutron spin filters and an XYZ field configuration for the sample environment and a polarization preserving neutron guide field. The complete system was calculated to provide adiabatic transport of the neutron polarization to the sample position while maintaining the homogeneity of the XYZ field. This system has now been tested on the polarized time of flight ESS test beamline V20 at Helmholtz Zentrum Berlin[3]. To the minimum wavelength of the instrument of 1.6 Å the magnetic configuration worked ideally neutron spin transport while giving full experimental freedom to change between the X, Y or Z field configuration. Additionally a graphite powder hydrated with H_20 was measured to verify performance under practical measuring conditions. The ^{3}He cell used was polarized at the ^{3}He lab in Garching and transported to HZ-Berlin via car in a permanent magnet transporter box. We present results of this test and the next steps forward.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Data corrections for neutron polarization simplified using an in-situ polarized ^{3}He neutron spin filter

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An in-situ polarized ^{3}He spin filter is in routine operation for the polarized reflectometer MARIA [1]. In order to properly analyize the data, correction for the imperfect efficiency of the polarizer analyzer and flippers is required. The proper way to perform these correction was nicely summarized in [2]. We use the method described there, however for our case of time-constant polarization and an ideal scattered-beam flipping efficiency they are greatly simplified. The resulting relations can be intuitively understood. We present the method for polarized data corrections on MARIA showing examples from polarized reflectometry and GiSANS experiments. A discussion of the resulting errors and sensitivity to the various correction terms will be discussed.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Polarization analysis for polychromatic chopper spectrometers

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Polarization analysis has been used in the field of neutron spectroscopy mainly on three axis instruments with the exception of the two modest resolution instruments D7 at the ILL and DNS at MLZ. At the new MW spallation sources mainly chopper spectrometers are/will be installed to study dynamics in condensed matter employing neutrons as a probe. In response to this several instruments have been developed [1, 2, 3], which realize PA on direct geometry chopper spectrometers. The significant increase in sample flux offers the potential to establish PA as a standard option also on chopper spectrometers. Here we discuss the implications of the polychromatic illumination of the sample for PA.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

New compact neutron supermirror transmission polarizer

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A new compact neutron supermirror transmission polarizer is suggested.The polarizer consists of a set of plates transparent to neutrons placed in the magnet gap. There are no air gaps between the plates. Polarizing supermirror coating without absorbing underlayer is deposited on the polished surfaces of the plates. Magnetic and nonmagnetic layers of the supermirror coating as well as the material of the plates have nearly equal neutron-optical potentials for spin-down neutrons. There is a considerable difference between neutron-optical potentials of layers in the supermirror structure for spin-up neutrons. As a result, spin-up neutrons reflect from the supermirror coating and deviate from their initial trajectories whereas spin-down neutrons do not practically reflect from the coating and, consequently, do not deviate from their initial trajectories. Thus, spin-down neutrons dominate near the axis of distribution of intensity on the angle for the beam transmitted through this polarizer, i.e., the beam is substantially polarized.

Application of this polarizer in a research facility for small angle scattering of monochromatic neutrons with wavelengths from 4.5 to 20 A is discussed. The polarizing cross section of the beam of this facility is 30x30 mm^2 and its angular divergence is 10 mrad. Calculated parameters of a polarizer on silicon plates with supermirror CoFe/TiZr (m = 2) a coating are presented. In particular, for transmitted beam of neutrons with wavelength 12.5 A, the polarizing efficiency and the transmission coefficient for spin-down neutrons are 0.99 and 0.88, respectively, in the case of the polarizer which length is only 22 mm.

The suggested polarizer is compared with solid state polarizers and V-cavity - widely known transmission neutron polarizer.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Multichannel supermirror analyzers of neutron polarization of fan type

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In recent years in polarizing neutron facilities two-coordinate position sensitive detectors with sensitive area not less than 400 cm2 were widely distributed. In this regard there was an urgent need in creation of the wide-angle analyzers of polarization allowing to carry out the polarizing analysis on all extensive area of the detected beam. Use of multichannel supermirror analyzers of polarization of fan type allows to solve this problem for a neutron reflectometry.
The neutron wide-angle supermirror analyzers of polarization of fan type created [1-3] and created now in PNPI (National Research Center “Kurchatov Institute”) for a neutron reflectometry are presented in the report.

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Tuesday, 05.07.2016, 17:45 Poster Session 2

Polarized neutron interferometer beamline for material research at National Institute of Standards and Technology.

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Perfect crystal neutron interferometer is one of the most sensitive tools to study neutron interaction with materials. Unfortunately, it is not widely used due to the narrow bandwidth energy acceptance of perfect crystal and extreme sensitivity to environmental noise such as low-frequency vibrations and temperature instabilities. Recent advances in quantum information and neutron interferometry have lead to the commissioning of a new neutron interferometer beam line (NIOFa) at the National Institute of Standards and Technology, Maryland, USA [1]. This beamline is based on decoherence-free subspace neutron interferometer design and dedicated to study novel materials and phase transitions.

Here we report this beamline’s neutron polarization and analyzing capabilities. This includes multilayered supermirror polarizers and their characterization at the beamline. Addition of the sample cold stage inside neutron interferometer will allow to study spintronic materials and magnetic phase transitions.

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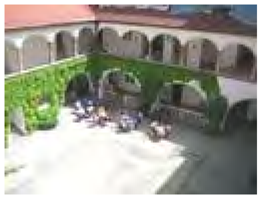
Location and Accommodation

The workshop venue is the Bildungszentrum Kardinal-Döpfner-Haus (www.bildungszentrum-freising.de) in Freising near Munich. All attendees will be accommodated in the conference centre or in the Hotel Bayrischer Hof (www.bayerischerhof-freising.de) nearby depending on capacity.



How to reach Freising

Freising is about 30 km south of the Munich airport. It is connected by train to the wider Munich public transportation system. Commuting time via public transportation from the Munich airport is about 25 min and from the Munich central station about 60 min.

How to reach the Bildungszentrum Kardinal-Döpfner Haus

From the center of Munich (approx. 60 minutes)

- At main station take the S1 (leaves every 20 minutes) in the direction of Freising. The ticket costs 8.10 EUR for 3 zones.
- From the S-Bahn station in Freising it is within 10 min walking to the Bildungszentrum at the Domberg.

From Munich airport (approx. 25 minutes)

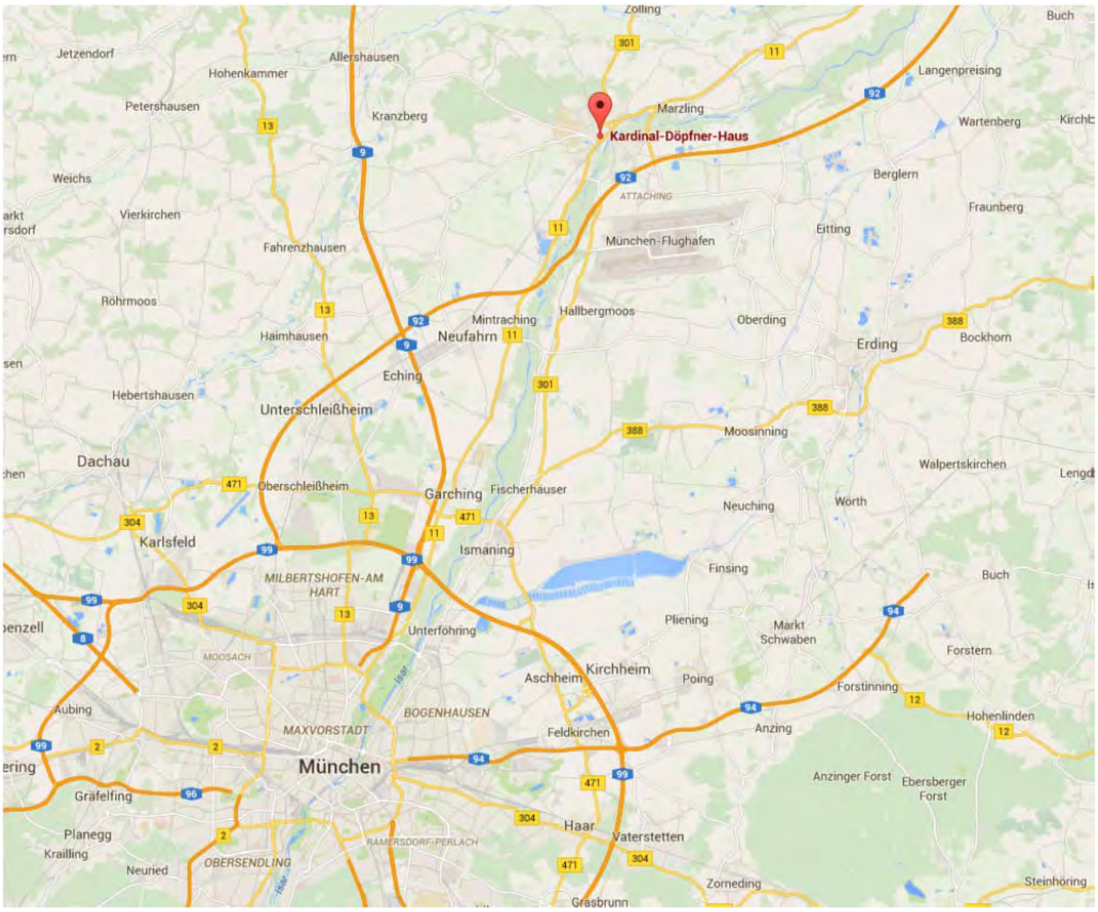
- If your flight ticket does not include a journey in the MVV area, your journey on the S-Bahn (city train) to Freising requires a day ticket for the external area (Außenraum) which costs 6.40 EUR, or a single ticket for 2.70 EUr for 1 zone..
- Take the S1 (in the direction of Munich Hauptbahnhof (main station) as far as Neufahrn station (two stops)
- At Neufahrn change trains to the opposite platform for the S1 to Freising.
- The Bildungszentrum Kardinal-Döpfner Haus is approx. 10 min walking distance from the S-Bahn station Freising at the Domberg.
- You may also take busline 635 from the aiport to Freising train station.

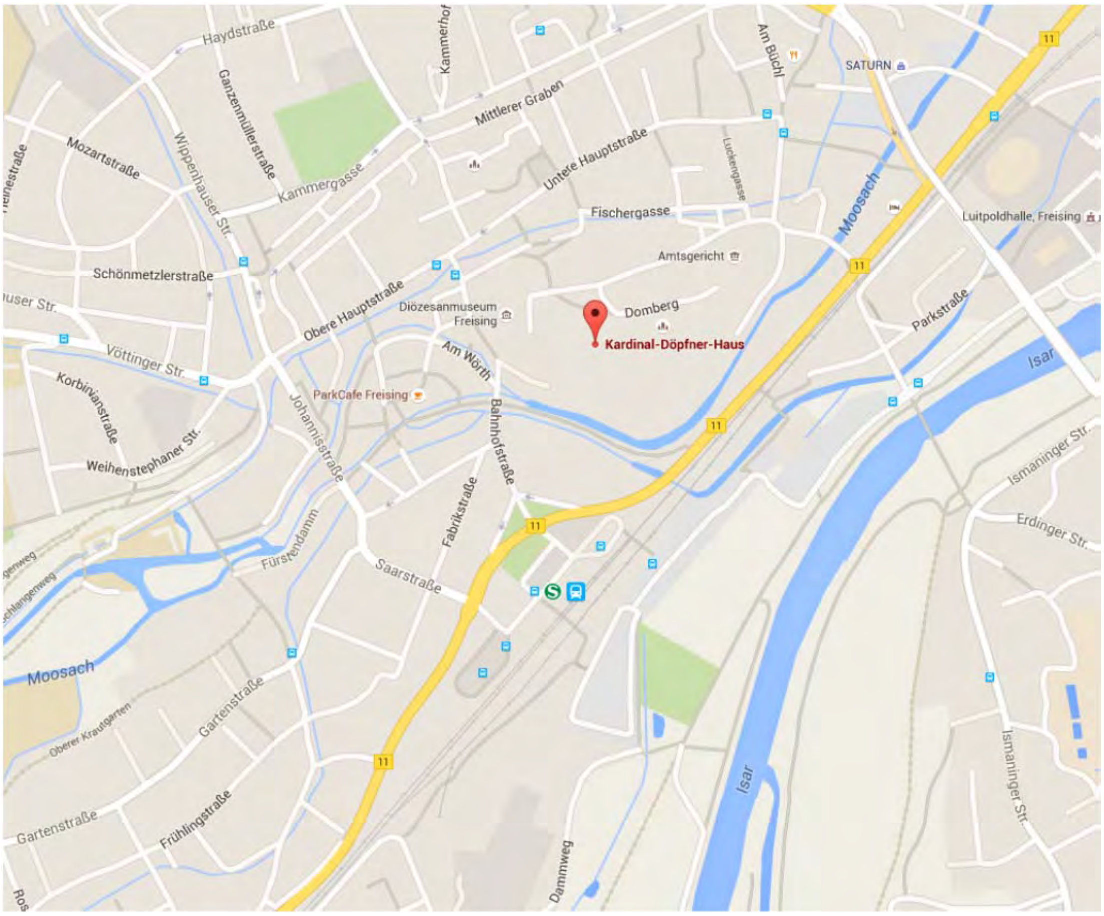
You can find information on the trainor bus schedule at the webpage of the Munich Public Transportation Service

http://www.mvv-muenchen.de/en/homepage/index.html

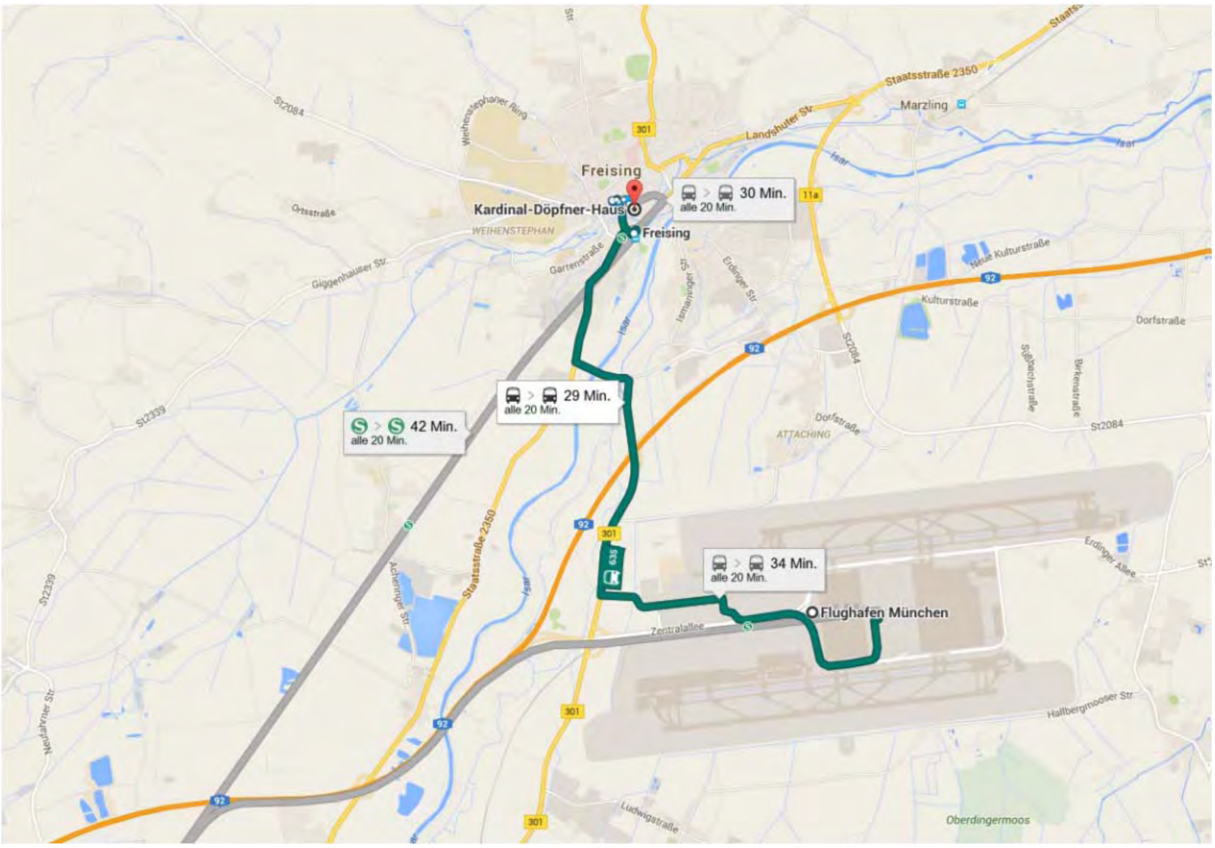
or the Deutsche Bahn service

http://www.bahn.de/p_en/view/index.shtml

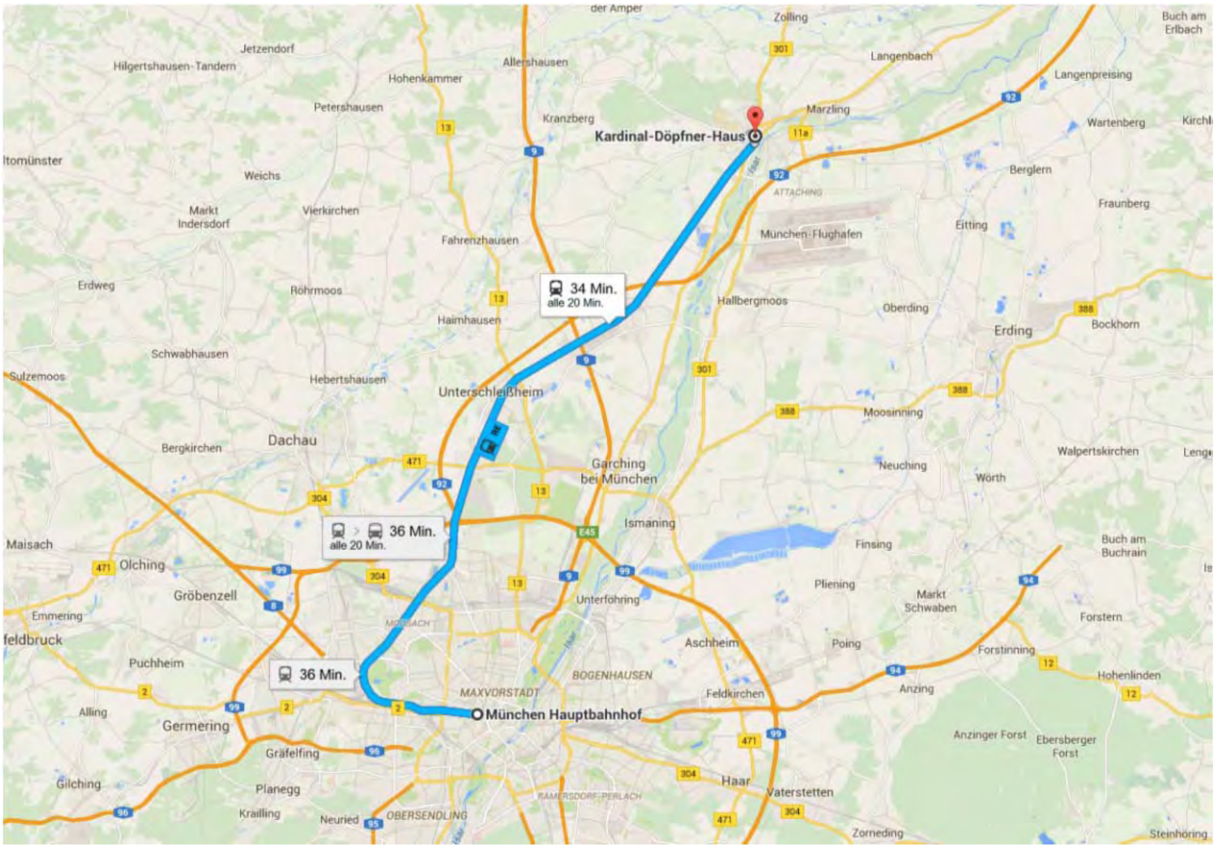




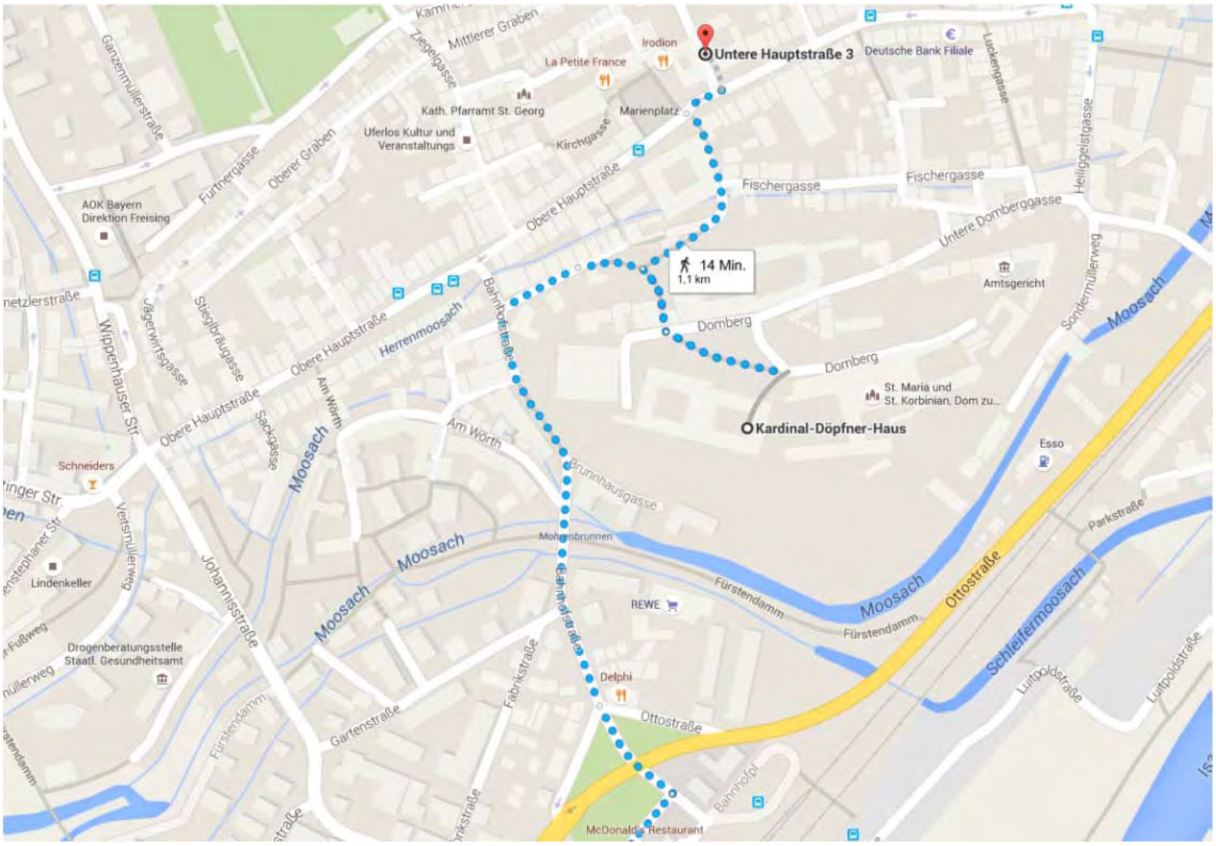
Transportation Munich airport to Freising with bus 635



Transportation Munich main station to Freising with suburban train S1



Walking from Freisng train station to the Kardinal-Döpfner-Haus and to Hotel Bayrischer Hof, Untere Hauptstr. 3



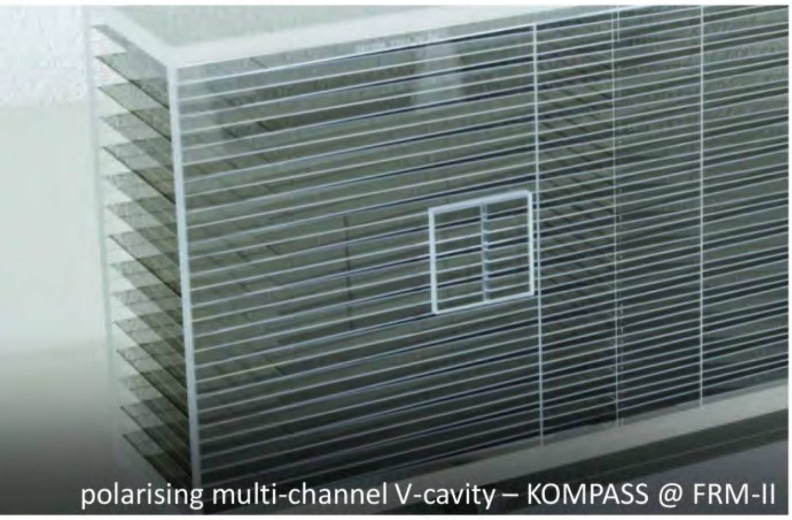
List of partcipants

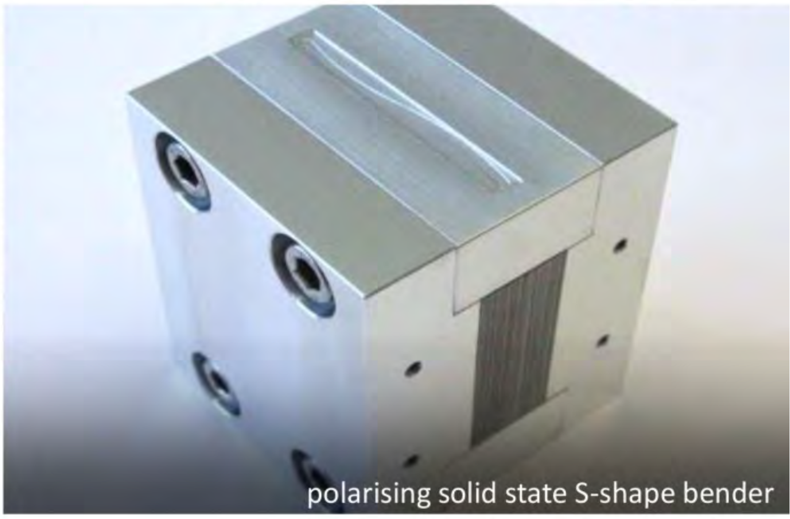
Prename	Name
Evgenii	Altynbaev
Masatoshi	Arai
Earl	Babcock
Thierry	Bigault
Viktor	Bodnarchuk
Peter	Böni
Philippe	Bourges
Thomas	Brückel
Dongfeng	Chen
Wangchun	Chen
Nadezhda	Chubova
Jae-Ho	Chung
Pierre	Courtois
Pengcheng	Dai
Robert	Dalglish
Mechthild	Enderle
Xavier	Fabreges
Björn	Fåk
Bela	Farago
Tom	Fennell
Artem	Feoktystov
Henrich	Frielinghaus
Zhendong	Fu
Ramil	Gainov
Marina	Ganeva
Robert	Georgii
Dustin	Gilbert
Artur	Glavic
Sergey	Grigoriev
Natalia	Grigoryeva
Felix	Groitl
Thomas	Gutberlet
Klaus	Habicht
Lijie	Hao
Linfeng	He
Kosuke	Hiroi
Olaf	Holderer
Vladimir	Hutanu
Ekaterina	Iashina
Takashi	Ino
Alexander	Ioffe
Oxana	Ivanova
Wentao	Jin
Kazuhisa	Kakurai
Thomas	Keller
Yury	Khaydukov
Hiroshi	Kira
Peter	Konik
Michael	Kotlarchyk
Sergey	Kozhevnikov
Evgeny	Kravtsov
Wolfgang	Kreuzpaintner
Thomas	Krist
Zaw Lin	Kyaw
Wai Tung	Lee
Dieter	Lott
Zsolt	Ludanyi
Bastian	Märkisch
Ryuji	Maruyama
Stefan	Mattauch
Vasilii	Matveev
Sina	Mayr
Siqin	Meng
Daniel	Merkel
Andreas	Michels
Sebastian	Mühlbauer
Bela	Nagy
Yusuke	Nambu
Shibabrata	Nandi
Kirill	Nemkovskiy
Gøran Jan	Nilsen
Jitae	Park
Stefano	Pasini
Konstantin	Pavlov
Alexander	Petukhov
Nikolay	Pleshanov
Dmitry	Pushin
Sabine	Pütter
Johannes	Reim
Karl	Ridier
Valentin	Sadilov
Thomas	Saerbeck
Zahir	Salhi

Andrei	Savici
Andrew	Sazonov
Christian	Schanzer
Wolfgang	Schmidt
Markus	Schmitz
Harald	Schneider
Michael	Schulz
Steffen	Schwesig
Marc	Seifert
Takenao	Shinohara
Ivan	Shishkin
Sven-Arne	Siegfried
Markos	Skoulatos
Oleg	Sobolev
Alexandra	Steffen
Ross	Stewart
Markus	Strobl
Yixi	Su
Xiao	Sun
Amir	Syed Mohd
Vladislav	Syromyatnikov
Vladislav	Tarnavich
Henrik	Thoma
Boris	Toperverg
Ad	van Well
Tamas	Veres
Egor	Vezhlev
Nicolò	Violini
Jörg	Voigt
Shannon	Watson
Frank	Weber
Barry	Winn
Jingfan	Ye
Paul	Zakalek
Igor	Zaliznyak
Igor	Zobkalo


wide angle polarisation anlyser – POLANO @ JPARC


1d focusing Heusler analyser – FLEX @ HZB


polarising multi-channel V-cavity – KOMPASS @ FRM-II


polarising solid state S-shape bender


polarising neutron guide – i-NSE @ JRR-M3


polarising multi-channel V-cavity with magnetic casing – RESEDA @ FRM-II

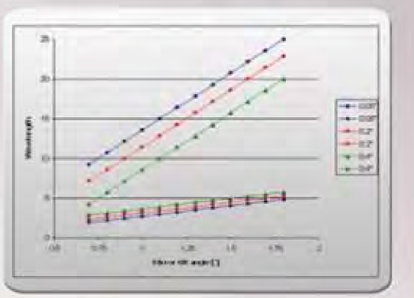
RF Flippers and Current Source

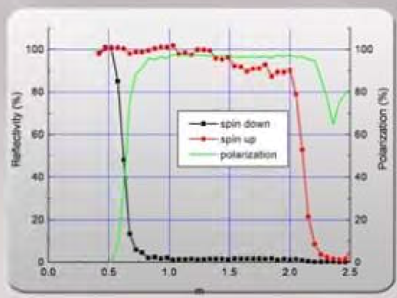

RF Flipper test setup


RF Current Source

Parameters

- Standard product
- Purpose Designed RF Current Source
- Current range: 0 – 22A controllable
- Frequency range: 170 – 500kHz extendable
- Limit voltage: 110Vpp
- Command output for balancing capacitor pad switching
- Remote control
- Overvoltage and overheating protection.





Transmission Polarizer with RF Flipper

MIRROTRON Ltd., Konkoly-Thege út 29-33, Budapest, H-1121
☎: (36-1) 392-2642, Fax: (36-1) 392-2282
e-mail: info@mirrotron.hu

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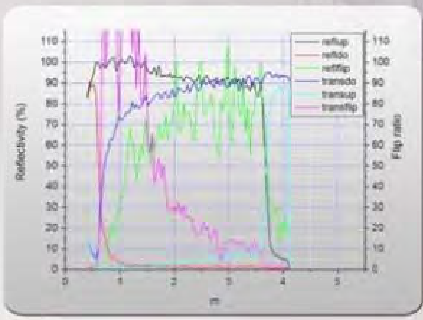
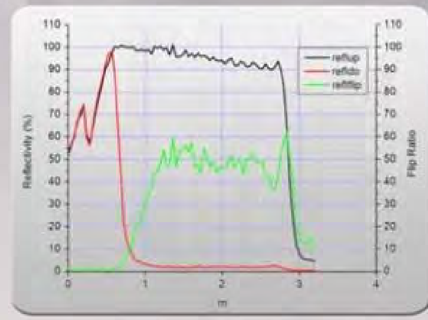
- Transmission Supermirror Polarizer
- S - bender
- RF Flippers
- RF Current Source / Power Supply
- Mezei flipper system

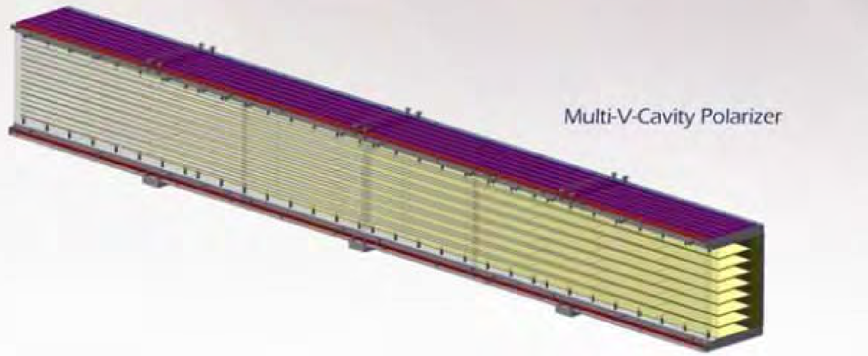
- Guide Field Magnet System

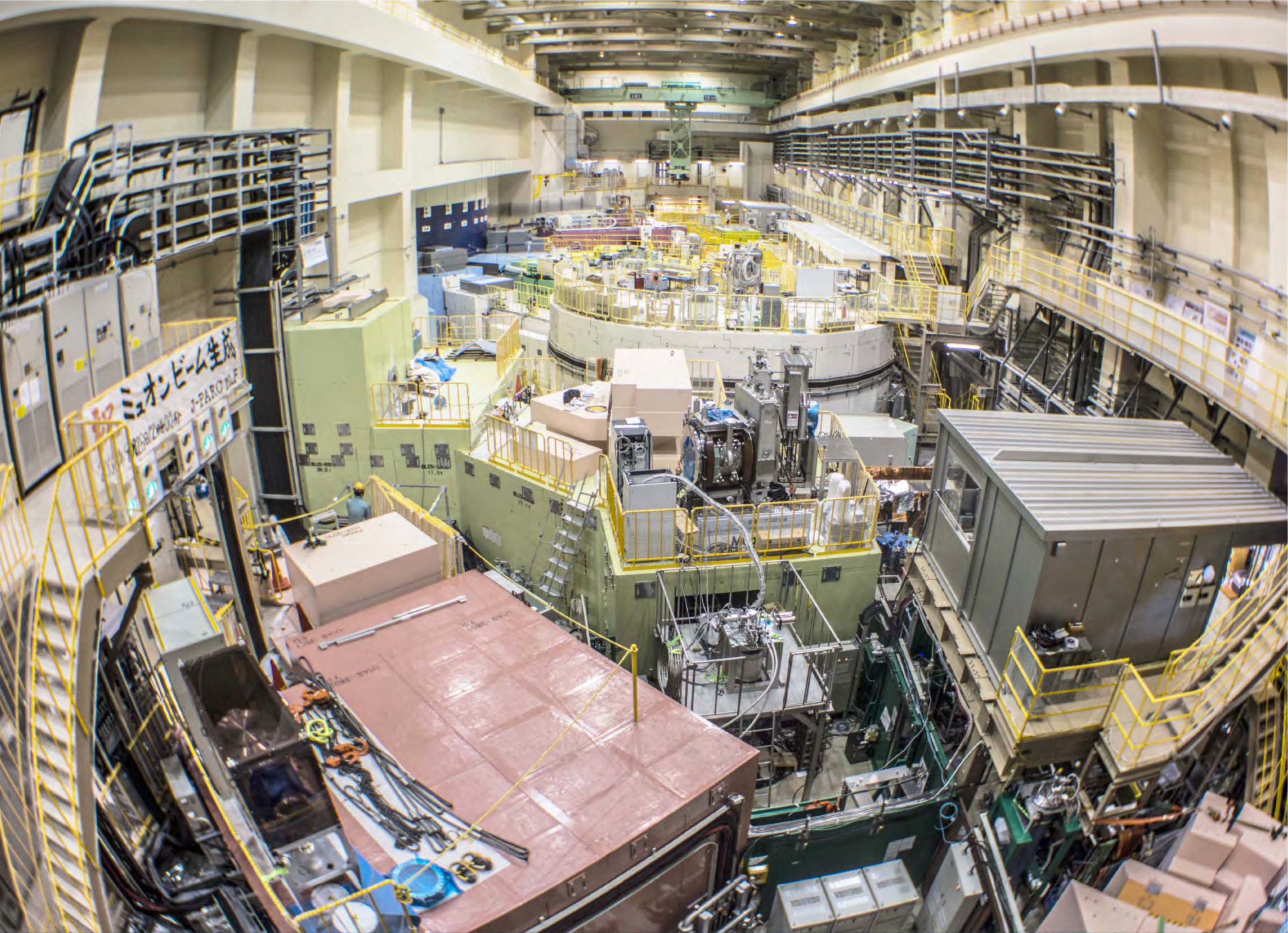
- Fe/Si polarizing supermirror
  m = 2.8, R = 90%, polarization = 96%
  New m = 3.6, R = 85%, polarization = 97%


S - bender






Multi-V-Cavity Polarizer



J-PARC MLF

物質・生命科学実験施設

- Mercury target(Hg)
- Three types of supercritical hydrogen moderators (Coupled, Decoupled, Poisoned)
- 23 beam ports
- 6.5×10^{13} neutron/pulse (The world's highest flux as of June 2013)

Neutron Source

Experimental facility of the world's most intense pulse neutron and muon sources.

There are 20 neutron instruments and 2 muon instruments constructed by JAEA,KEK,Ibaraki pref., and universities at MLF. Currently instruments for neutron (BL23) and muon (U) are under construction.

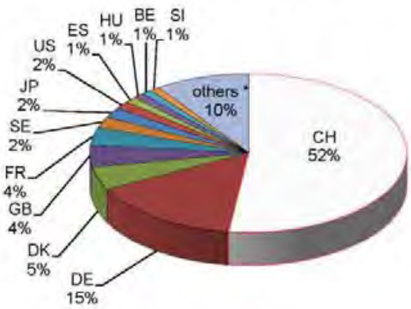
Materials and Life Science Experimental Facility

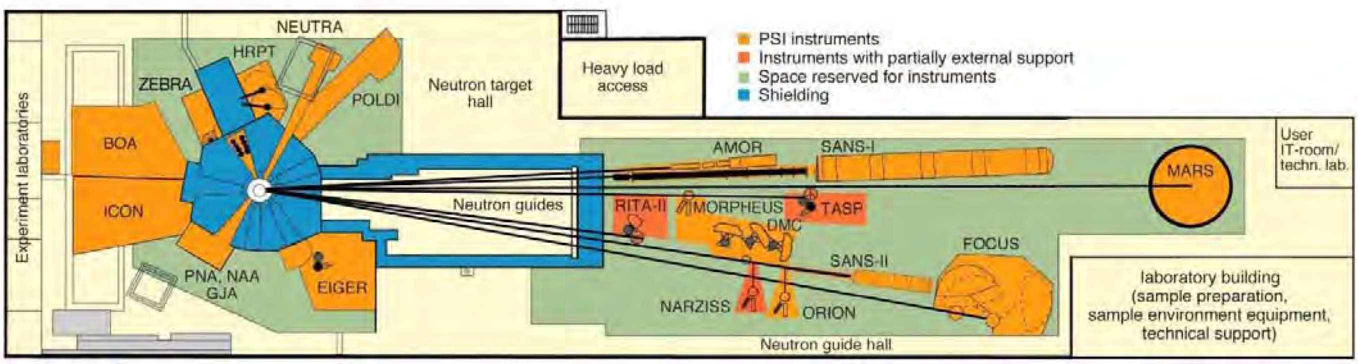
PAUL SCHERRER INSTITUT

The Paul Scherrer Institute PSI is the largest research center for natural and engineering sciences in Switzerland, conducting cutting-edge research in three main fields: matter and materials, energy and environment and human health. PSI develops, builds and operates complex large-scale research facilities. Every year, more than 2200 scientists from Switzerland and around the world come to PSI to use our unique facilities to carry out experiments that are not possible anywhere else. PSI is committed to the training of future generations. Therefore about one quarter of our staff is apprentices, post-graduates or post-docs. PSI employs 1900 people, with an annual budget of approximately CHF 380 million, and is primarily financed by the Swiss Confederation.

SINQ – Swiss Continuous Spallation Neutron Source

The spallation neutron source SINQ is a continuous source with a flux of about 10^{14} n/cm^2/s. The flux has been steadily increased in the last 10 years by a factor of 4 by improving the proton accelerator and the target concept. A second target station (UCN) providing ultra-cold neutron has been added in 2010. The Laboratory for Neutron Scattering and Imaging (LNS) is offering SINQ a wide instrumentation park for diffraction, inelastic and small angle scattering, imaging as well as for engineering. Although the facility is fully Swiss financed, it is widely used by the European and international community. Access is granted based on scientific merit by an international advisory committee. Together with the Swiss Light Source SLS, the Swiss Muon Source SμS and the new free electron laser SwissFEL, Paul Scherer Institute is a unique campus for the investigation of novel sustainable materials in the field of condensed matter, biology and engineering.





Deadlines for beam application: May 15 and Nov.15
useroffice@psi.ch www.psi.ch/sinq www.psi.ch/lns

Heinz Maier-Leibnitz Zentrum

The Heinz Maier-Leibnitz Zentrum (MLZ)

The Heinz Maier-Leibnitz Zentrum is a leading centre for cutting-edge research with neutrons and positrons. Operating as a user facility, the MLZ offers a unique suite of high-performance neutron scattering instruments. This cooperation involves the Technische Universität München, the Forschungszentrum Jülich and the Helmholtz-Zentrum Geesthacht. The MLZ is funded by the German Federal Ministry of Education and Research, together with the Bavarian State Ministry of Education, Science and the Arts and the partners of the cooperation.

Bavarian State Ministry of Education, Science and the Arts

SPONSORED BY THE

Federal Ministry of Education and Research

MLZ is a cooperation between:

JÜLICH FORSCHUNGSZENTRUM

Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

Technische Universität München

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Neutron Velocity Selectors

More than 70 selectors supplied worldwide used as monochromator or as higher-order filtre

- thin blades (CFRP) -> low surface losses
- lightweight construction -> high speed -> short length
- length 0.25m -> low gap losses
- low divergency losses
- high transmission (upto 96%)
- high resolution $d\lambda/\lambda$ for use as monochromator
- 32 – 144 blades
- upto 160 mm blade height
- wavelength range: 1.0 – 60 Å
- extension of wavelength- and/or resolution range by tilt-table or goniometer


10% resolution


5% resolution

Neutron Disc Chopper Systems

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- key-ready systems with control- and monitoring system
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- absorber material: B_{10} or Gd_2O_3
- bearings: hybrid ball bearings or active magnetic bearings
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Neutron Fermi Chopper Systems

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- speed: upto 40,000 rpm
- absorber material: B_{10} or Gd_2O_3
- bearings: hybrid ball bearings or active magnetic bearings


Slit/Slat Package

contact:
berno.spiegelhalder@airbus.com

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The Jülich Centre for Neutron Science (JCNS) develops and operates neutron scattering instruments at leading neutron sources. Through our work, we aim to help address the grand challenges of modern society. Our in-house research focuses on Correlated Electron Systems and Nanomagnetism **as well as** Soft Matter and Biophysics. **In these areas, we offer expert support to users of our world-class instruments with specialized sample environments and ancillary laboratory access.**

Our equipment:

- 11 neutron scattering instruments at the newly-established Heinz Maier-Leibnitz Zentrum (MLZ) at the neutron source FRM II, often in close cooperation with its partners
- two more instruments currently under construction
- one instrument at ILL, one at SNS, beamtime at four additional instruments
- our instruments are regularly optimized to meet future needs

Further information can be found at **jcns.de** and **mlz-garching.de**.

Member of the Helmholtz Association