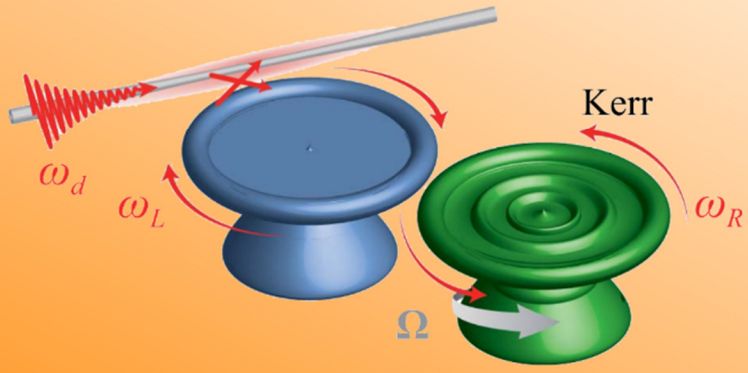
QuTecNOMM'19

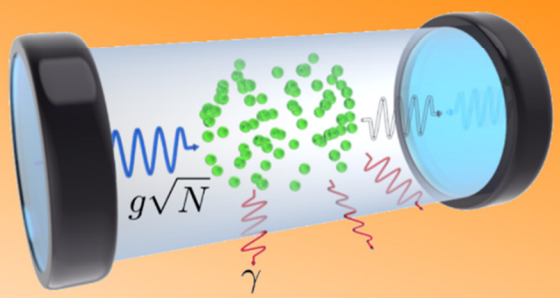
15.10–18.11.2019

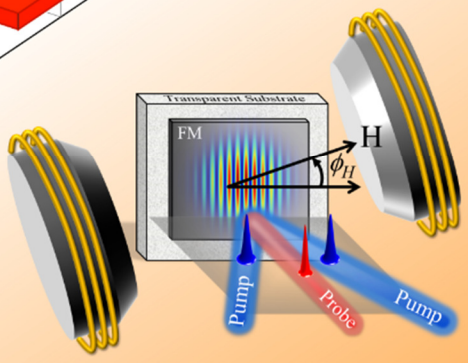
Quantum Technologies, Nonlinear Optics, Magnonics, and Metamaterials

Invited speakers - session „Magnonics and metamerials"

Gabriel D. Chaves-O'Flynn (Poznań)
Ryszard Gieniusz (Białystok)
Bartłomiej Graczykowski (Poznań)
Joachim Gräfe (Stuttgart)
Liubov Ivzhenko (Khakiv)
Andrzej Janutka (Wrocław)
Jan Kisielewski (Białystok)
Maciej Krawczyk (Poznań)
Piort Kuświk (Poznań)
Tadeusz Lulek (Poznań)
Sławomir Mamica (Poznań)
Justyna Rychły (Poznań)
Radosław Strzałka (Kraków)
Piotr Tomczak (Poznań)
Jakob Walowski (Greifswald)
Andrzej Wawro (Warszawa)
Mirosław Werwiński (Poznań)
Kacper Wrześniewski (Poznań)
Karol Załęski (Poznań)
Piotr Zieliński (Kraków)







Main organizers of the Sessions on

Quantum Technologies and Nonlinear Optics:
Adam Miranowicz, Krzysztof Grygiel,
Karol Bartkiewicz, and Grzegorz Chimczak

Magnonics and Metamaterials:
Jarosław Kłos, Sławomir Mamica,
and Paweł Gruszecki

UAM

Adam Mickiewicz University in Poznań, Faculty of Physics
ul. Uniwersytetu Poznańskiego 2, 61-614 Poznań, Poland

The Symposium QuTecNOMM 2019 took place on October 15th (Tuesday), October 18th (Friday), October 23th (Wednesday), and November 14-18th (Thursday-Monday) at the Faculty Physics, Adam Mickiewicz University (UAM), Poznań, Poland

The Symposium is organized by
the Nonlinear Optics Division and the Nanomaterials Physics Division of UAM.

The programme is focused mainly on Quantum Technologies including:

- Nonlinear Optics
- Plasmonics & Photonics

and Magnonics and Metamaterials including:

- Magnonic Crystals and Quasicrystals
- Phononics and Magneto-elastic Interactions
- Skyrmions
- Phase-sensitive Effects in Magnonics
- Magnonic Systems under External Bias
- Magnetic Systems – Fabrication

This Symposium commemorates Prof. Stanisław Kielich (1925-1993)

The programme and abstracts for the second part of the Symposium

Sessions about Magnonics and Metamaterials

PROGRAMME

Thursday, 14 Nov 2019
room 16 (in the front of the dean's office)

9:35-9:40 opening

Session I on Magnonics and Metamaterials
chairman: Sławomir Mielcarek

- 9:40-10:00 Bartłomiej Graczykowski (UAM Poznań): Nanoscale silicon thermaldiode and switch (invited talk)
- 10:05-10:20 Nandan K. P. Babu (UAM Poznań): *Detectionof magnon-phonon Interactions using BLS spectroscopy in CoFeB/Au multilayerstructure*
- 10:25-10:40 Miłosz Zdunek (UAM Poznań) Interaction between thermal magnons and phonons in [Ni80Fe20/Au/Co/Au]10 multilayer
- 10:45-11:00 Oleksandr Chumak (IF PAN Warszawa): *Strain Modulated Ferromagnetic Resonance technique and it's application for Co2YZ Heusler thin films investigation*

11:05-11:20 COFFEE BREAK

Session II on Magnonics and Metamaterials
chairman: Jarosław W. Kłos

- 11:20-11:40 Radosław Strzałka (AGH Kraków): *New approach to structural disorder in aperiodic systems – example of decagonal AlCuRh quasicrystal* (invited talk)
- 11:45-12:00 Szymon Mieszczak (UAM Poznań): *Spin wave localization on phasonic defects in magnonic quasicrystal*

12:05-13:35 LUNCH BREAK

Session III on Magnonics and Metamaterials
chairman: Piotr Zieliński

- 13:35-13:55 Gabriel Chaves-O'Flynn (IFM PAN Poznań): *Activation barriers for creation and annihilation of magnetic droplet solitons* (invited talk)
- 14:00-14:15 Mateusz Zelent (UAM Poznań): *Formation and driving by electric current of Neel type skyrmion in antidot lattices*
- 14:20-14:35 Krzysztof Szulc (UAM Poznań): *Spin-wave diode and circulator*
- 14:40-15:00 Maciej Krawczyk (UAM Poznań): *Spin wave dynamics in complex magnetization textures* (invited talk)

15:05-15:20 COFFEE BREAK

Session IV on Magnonics and Metamaterials
chairman: Andrzej Janutka

- 15:20-15:40 Piotr Tomczak (UAM Poznań): *Universal FMR procedure to probe magnetic characteristics of ferromagnetic samples* (invited talk)
- 15:45-16:05 Sławomir Mamica (UAM Poznań): *Nonuniform softening of spin waves in 2D magnonic crystals* (invited talk)
- 16:10-16:30 Piotr Zieliński (IFJ PAN Kraków): *Static configurations and spin wave dynamics in finite magnetic chains: from simplified models to micromagnetic calculations* (invited talk)
- 16:35-16:55 Tadeusz Lulek (UAM Poznań): *Algebraic Bethe Ansatz as a tool for quantum information processing* (invited talk)

Friday, 15 Nov 2019

Kielich's Auditorium

Session V on Magnonics and Metamaterials
chairman: Paweł Gruszecki

- 9:00-9:20 Jakob Walowski (Greifswald, Germany): *Spin-wave packats triggered by ultrashort laser pulses* (invited talk)
- 9:25-9:45 Joachim Gräfe (Stuttgart, Germany): *Imaging nanoscale spin dynamics using x-ray microscopies* (invited talk)
- 9:50-10:10 Justyna Rychły (IFM PAN, Poznań): 1D *Fibonacci magnonic quasicrystals – self-similarity of spin wave spectra, spin waves localization, and reprogrammability* (invited talk)

10:15-10:30 COFFEE BREAK

Session VI on Magnonics and Metamaterials
chairman: Joachim Gräfe

- 10:30-10:50 Andrzej Janutka (PWr Wrocław): *Magnetoreactance at the nanoscale* (invited talk)
- 10:55-11:15 Emerson Coy (UAM Poznań): *Nanoindentation Applications for Oxide Electronics*
- 11:20-11:40 Andrzej Wawro (IF PAN Warszawa): *Spatial ion beam modifications of Co layered structures – a recipe for magnonic crystals* (invited talk)
- 11:45-12:05 Ewelina Milińska (IF PAN Warszawa): *Magnetization reversal, domain structure and ferromagnetic resonance of heavy metal/ferromagnetic heterostructures*

12:10-13:40 LUNCH BREAK

Session VII on Magnonics and Metamaterials
chairman: Hubert Głowiński

- 13:40-14:00 Ryszard Gieniusz (UWB Białystok): *Magnetooptical and Brillouin Light Scattering studies of ultrathin Co wedges with Pt and Ir covers* (invited talk)
- 14:05-14:20 Anuj K. Dhiman (UWB Białystok): *Magnetic properties of Ir/Co/Pt and Pt/Co/Ir multilayers with Dzyaloshinskii-Moriya interaction*
- 14:25-14:45 Jan Kisielewski (UWB Białystok): *Mapping magnetic textures in films with Dzyaloshinskii-Moriya interaction* (invited talk)

14:50-15:05 COFFEE BREAK

Session VIII on Magnonics and Metamaterials
chairman: Emerson Coy

- 15:05-15:25 Mirosław Werwiński (IFM PAN Poznań) *Magnetocrystalline anisotropy of L10 FeNi from DFT* (invited talk)
- 15:30-15:45 Piotr Rzeszut (AGH Kraków): *Serially connected perpendicular magnetic tunnel junctions formulti-bit STT-MRAM storage cells and neuromorphic computing*
- 15:50-16:10 Piotr Graczyk (IFM PAN Poznań): *Nonresonant amplification of coherent spin waves through voltage-induced interface magnetoelectric effect and spin-transfer torque*
- 16:15-16:35 Hubert Głowiński (IFM PAN Poznań): *Ion bombardment influence on magnetization damping*
- 16:40-17:00 Piotr Kuświk (IFM PAN Poznań): *Local modification of magnetic properties for potential applications in magnonics* (invited talk)

Monday, 18 Nov 2019

room 16 (in the front of the dean's office)

Session IX on Magnonics and Metamaterials
chairman: Maciej Krawczyk

- 9:00-9:20 Kacper Wrześniewski (UAM Poznań): *Quench dynamics of spin in magnetic impurity systems* (invited talk)
- 9:25-9:45 Karol Załęski (UAM Poznań): *Thin films of Heusler alloy Co2FeSi on graphene and HOPG–the candidate for highly spin-polarized injector for graphene spintronics* (invited talk)

9:50-10:05 SHORT BREAK

Session X on Magnonics and Metamaterials
chairman: Sławomir Mamica

- 10:05-10:25 Liubov Ivzhenko (Kharkiv, Ukraine): *Experimental and numerical identification of Faraday effect enhancement by all-ferrodielectric metasurface* (invited talk)
- 10:30-10:45 Mateusz Gołębiewski (UAM Poznań): *Talbot effect for spin waves*
- 10:50-11:05 Krzysztof Sobucki (UAM Poznań): *Subwavelength control of the phase of spin waves by ferromagnetic resonators*

ABSTRACTS - talks

- Authors: N. K. P. Babu, A. Trzaskowska, S. Mielcarek, H. Głowiński, P. Kuświk, F. Stobiecki, M. Zdunek, P. Graczyk, J. W. Kłos, G. Centała, M. Krawczyka.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Detection of magnon-phonon Interactions using BLS spectroscopy in CoFeB/Au multilayer structure*

Abstract: The investigations about the phenomena involving interactions between thermal magnons and phonons have grate interest in modern emerging field of spintronics. In our studies, we determine the dispersion relation of thermal magnons and phonons in the CoFeB/Au multilayer deposited on a silicon substrate with Ti and Au buffer layers using Brillouin light scattering spectroscopy. We choose two geometries oblique geometry, (where the angle between magnetic field and wave vector is 45°) and Backward volume geometry (where the magnetic field and wave vector are perpendicular to each other). We found three different types of spin waves (Backward volume mode (BV-SW), perpendicular standing mode (PS-SW) and Damon-Eshbach mode (DE-MSW) and two phonon modes (Rayleigh (R-SAW) and Sezawa (S-SAW).

- Authors: O.M. Chumak.

Affiliation of the presenting author:
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Title: *Strain Modulated Ferromagnetic Resonance technique and it's application for Co_2YZ Heusler thin films investigation*

Abstract: The unique Strain Modulated Ferromagnetic Resonance (SMFMR) technique will be presented, which allows determination of the magnetoelastic properties of thin magnetic films or ribbons, viz. magnetoelastic constants of the material. The SMFMR technique is successfully applied for investigation of thin layers of $Co_2Fe_xMn_{1-x}Si$ ($CF_xM_{1-x}S$), $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) and $Co_2FeGa_{0.5}Ge_{0.5}$ (CFGG) Heusler alloys. The alloys mentioned above are characterized by high spin polarization and are good candidates for technical applications, among others in spintronics and magnonics; the magnetoelastic properties, magnetic anisotropy and dissipative properties play an important role in these materials. Several effects are investigated: the effect of the magnetic layer composition changing ($CF_xM_{1-x}S$), the finite thickness of the magnetic layer and the use of various buffer and surface layers (CFMS and CFGG).
This work is partially supported by the National Science Centre of Poland – project number 2018/31/B/ST7/04006.

- Authors: Emerson Coy.

Affiliation of the presenting author:
NanoBioMedical Centre, Adam Mickiewicz University,Wszechnicy Piastowskiej 3 61-614 Poznan, Poland

Title: *Nanoindentation Applications for Oxide Electronics*

Abstract: Nanoindentation is a well-established characterization technique for the extraction of mechanical information of nanomaterials. Nevertheless, much of the potential of the technique is still overlooked by the functional oxides and the electronics community, due to traditional preconceptions about their applicability and use. In this talk, some of the unique capabilities of the technique will be discussed. Followed by specific applications on different materials such as flexoelectric, ferroelectric and ferromagnetic. Finally, the potential of nanoindentation as a powerful tool for information technology, energy, and communications, will be presented.

- Authors: A.K. Dhiman, R. Gieniusz, H.Głowiński, Z. Kurant, M. Matczak, F. Stobiecki, I.Sveklo, M.Tekielak, A.Maziewski.

Affiliation of the presenting author:
Faculty of Physics, University of Bialystok, Bialystok, Poland

Title: *Magnetic properties of Ir/Co/Pt and Pt/Co/Ir multilayers with Dzyaloshinskii-Moriya interaction*

Abstract: [Co(d_{Co})/Pt(d_{Pt})/Ir(d_{Ir})]N and [Co(d_{Co})/Ir(d_{Ir})/Pt(d_{Pt})]N multilayers were deposited by magnetron sputtering. Different dCo was chosen to approach spin reorientation transition SRT from perpendicular to in-plane magnetization state. Different coupling between layers was obtained changing spacer layers thicknesses dIr and dPt. Investigation of magnetic characterization was done using longitudinal and polar magneto-optical Kerr effect MOKE, vibrating sample magnetometer VSM, Brillouin light scattering BLS spectroscopy, magnetic force microscopy MFM, VNA-FMR and FMR spectroscopy. The following magnetization distribution was deduced from magnetization curves and magnetic domain imaging: large macrodomain (micrometer size) differentiated by in-plane “core” magnetization modulated by small nano-domain differentiated by out-of-plane magnetization. Hysteresis of BLS signal (measured also without magnetic field) was found. The in-plane “core” magnetization in domains seems to be responsible for BLS signal.
Work supported by Polish National Science Center projects: DEC-2016/23/G/ST3/04196 Beethoven and UMO-2018/28/C/ST5/00308 SONATINA.

- Authors: Ryszard Gieniusz, Michał Matczak, Anuj K. Dhiman, Iosif Sveklo, Zbigniew Kurant, Urszula Guzowska, Feliks Stobiecki, Andrzej Maziewski .

Affiliation of the presenting author:
Faculty of Physics, University of Bialystok, Bialystok, Poland

Title: *Magnetooptical and Brillouin Light Scattering studies of ultrathin Co wedges with Pt and Ir covers*

Abstract: Ir/Co/Pt and Pt/Co/Ir trilayers with a wedged Co layer (Co thickness d=0±3.6nm) were deposited by magnetron sputtering on naturally oxidized Si substrates with a Ta/Au buffer. Their magnetic properties have been investigated using magneto-optical polar Kerr effect and Brillouin light scattering (BLS) technique in the Damon-Eshbach geometry. We have employed Brillouin Light Scattering spectroscopy in backscattering geometry for DMI constant D_S and spectral linewidths studies. D_S was nearly two times larger for the Ir/Co/Pt trilayer than for the Pt/Co/Ir with opposite chirality. The effective uniaxial magnetic anisotropy and Ds depend non-monotonically on d with a maximum at d≈1.2 nm. The asymmetry in linewidth for Stokes and anti-Stokes peaks is observed for both Ir/Co/Pt and Pt/Co/Ir trilayers for d < 1.6 nm, and it is increasing with decrease of Co thickness.
Acknowledgements: Supported by Polish National Science Center projects: DEC-2016/23/G/ST3/04196 Beethoven and UMO-2018/28/C/ST5/00308 SONATINA.

- Authors: Hubert Głowiński, Piotr Kuświk, Filip Lisiecki, and Błażej Anastaziak .

Affiliation of the presenting author:
Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland

Title: *Ion bombardment influence on magnetization damping*

Abstract: Both anisotropy and damping is a function of spin-orbit coupling (SOC). It is commonly observed that the damping increases with increasing perpendicular magnetic anisotropy (PMA). It is believed that this is due to their relation to SOC. We have studied Au/Co/Au samples after ion bombardment, which is a known method to modify PMA. We have found that although PMA changes significantly nonmonotonically with ion fluence, the damping changes monotonically. In summary, we believe that the connection between damping and PMA is not a simple relation to SOC.
This work was supported by DAAD within the program PPP Polen 2018 under Grant No. 57392264

- Authors: Mateusz Gołębiewski, Paweł Gruszecki, Andriy Serebryannikov, and Maciej Krawczyk.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Spin-wave Talbot effect in thin ferromagnetic film*

Abstract: Demonstration, in micromagnetic simulation, the self-imaging phenomenon (called the Talbot effect) for spin waves propagation in thin ferromagnetic film magnetized out-of-plane. We show that the diffraction grating created by the holes in thin permalloy film allows obtaining Talbot's carpets formed by the transmitted spin waves at high frequencies, where the exchange interactions dominate, and at low frequencies where the magnetostatic interactions influence the shape of the dispersion relation. The analyzed effect is particularly interesting due to the potential application in magnonic devices, e.g. logic circuits.

- Authors: Piotr Graczyk and Maciej Krawczyk.

Affiliation of the presenting author:
Institute of Molecular Physics, Polish Academy of Sciences, M. Smoluchowskiego 17, 60-179 Poznan, Poland

Title: *Nonresonant amplification of coherent spin waves through voltage-induced interface magnetoelectric effect and spin-transfer torque*

Abstract: Spin waves are a promising candidates as a carriers for the next-generation low-energy signal processing devices. Here, we present the operation and we analize the performance of the device which amplifies and modulates the spin wave by the ac electric field through the spin-transfer torque. Although the spin-transfer torque is regarded as a non-selective effect, i.e., it affects all the spin-wave modes together with noise, in our work we investigate the mechanism of this torque which is related to the specific spin wave symmetry and group velocity. As a consequence, it affects only coherent spin-wave modes but not noise. The system consists of two high-κ dielectric thin-film capacitors separated by ferromagnetic bilayer. The magnetization dynamics is affected non-resonantly with an ac voltage applied to such heterostructure by the spin accumulation. The spin accumulation is generated by the charge-mediated magnetoelectric effect (i.e., spin-dependent surface screening) and interacts with magnetization through the so-called field-like and anti-damping spin transfer torques. The spin transfer torques lead to the periodic spin wave ampilfication and attenuation with the frequency of the applied ac voltage. We show the criteria for the effective amplification and dependences of the obtained gain on the applied voltage amplitude and spin wave frequency. The generation of nonequilibrium spin density through dynamic spin-dependent surface screening in the proposed magnetoelectric heterostructure allows to reduce the thickness of fixed magnetization layer used in conventional spin valve to a few nanometers, thus the proposed effect can significantly contribute to miniaturization of the spintronic devices.
The study has received financial support from the National Science Centre of Poland under grant 2018/28/C/ST3/00052.

[1] P. Graczyk, M. Krawczyk, Spin-polarized currents driven by spin-dependent surface screening, arXiv:1902.06481

- Authors: M. Kasprzak, M. Sledzinska, K. Zaleski, I. Iatsunskyi, S. Volz, F. Alzina, C. M. Sotomayor Torres, and B. Graczykowski.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Nanoscale silicon thermal diode and switch*

Abstract: The recent research has pointed to nanostructuring as a highly efficient approach to reducing thermal conductivity. One example of nanostructured materials are porous/holey phononic crystals (PnCs), which thermal conductivity can be engineered by means of the surface-to-volume ratio and surface roughness. Tuneable thermal properties make these structures good candidates for integrated heat management devices, for instance for waste heat recovery or heat rectification. In particular, the thermal rectification means that the magnitude of heat flux changes when the temperature gradient is reversed in direction. As a step towards heat rectification using silicon porous membranes in this work, we studied both thermal conductivity and its temperature dependence on a geometric parameter, i.e. the surface-to-volume ratio.

- Authors: Joachim Gräfe.

Affiliation of the presenting author:
Max Planck Institute for Intelligent Systems, Stuttgart, Germany

Title: *Spin-wave packats triggered by ultrashort laser pulses*

Abstract: State of the art x-ray microscopy allows an unprecedented insight into dynamic magnetic systems, featuring a spatial resolution of 20 nm and a temporal resolution of 20 ps. This technique uniquely allows us real space observation of artificial spin systems that have been created using contemporary nanolithography methods. To this end we have developed sophisticated measurement and evaluation techniques that allow the fast acquisition of full spin wave dispersion relations and the quantitative measurement of minute spin angles. We showcase this technique with three examples: magnetic droplets, magnetic skyrmions, and short wavelength spin waves.

- Authors: Liubov Ivzhenko Sergey Polevoy, Vladimir Yachin, Boris Chichkov, and Sergey Tarapov.

Affiliation of the presenting author:
Radiospectroscopy Dept., IRE NAS of Ukraine, Kharkiv, Ukraine

Title: *Experimental and numerical identification of Faraday effect enhancement by all-ferrodielectric metasurface*

Abstract: We demonstrate a design of all-ferrodielectric metasurface which exhibit sufficient enhancement of the Faraday rotation induced by particular grating mode excitation [1,2]. The metasurface is presented as periodic arrangement of cylinders (open dielectric resonators) which located on the substrate and both made of ferrodielectric. The conditions of the grating mode excitation are revealed for different geometrical parameters of the resonators forming the array. It was established that the Faraday rotation [3,4] is increased in several times versus uniform ferrodielectric layer with the same thickness at the corresponding resonant frequency. The effect is confirmed in the microwave measurements.

[1] V. I. Belotelov, I. A. Akimov, M. Pohl, V. A. Kotov, S. Kasture, A. S. Vengurlekar, A. V. Gopal, D. R. Yakovlev, A. K. Zvezdin, and M. Bayer, “Enhanced magneto-optical effects in magnetoplasmonic crystals,” Nature Nanotechnology 6, 370-376 (2011).
[2] A. V. Chetvertukhin, A. A. Grunin, A. V. Baryshev, T. V. Dolgova, H. Uchida, M. Inoue, and A. A. Fedyanin, “Magneto-optical Kerr effect enhancement at the Wood’s anomaly in magnetoplasmonic crystals,” J. Magn. Magn. Mater. 324, 21, 3516–3518 (2012). [3] M. Inoue, M. Levy, and A. V. Baryshev, (Eds.). Magnetophotonics: From Theory to Applications (Springer Science & Business Media, 2013).
[4] A. A. Girich, S. Y. Polevoy, S. I. Tarapov, A. M. Merzlikin, A. B. Granovsky, and D. P. Belozorov, “Experimental Study of the Faraday Effect in 1D-Photonic Crystal in Millimeter Waveband,” Solid State Phenomena 190, 365-368 (2012).

- Authors: Andrzej Janutka.

Affiliation of the presenting author:
Department of Theoretical Physics, Wroclaw University of Science and Technology, 50-370 Wrocław, Poland

Title: *Magnetoreactance at the nanoscale*

Abstract: Magnetoreactance is a magnetic-field dependence of the imaginary part of the electrical impedance. While giant magnetoimpedance (GMI) of ferromagnetic microwires or sandwiched multilayers is being widely applied for sensing magnetic field with a superior field sensitivity, it is suppressed at the nanoscale in the accessible (microwave) range of the current frequency, which limits the spatial resolution of the sensors. A giant magnetoreactance (GMX), that is assisted by driven oscillations of the ferromagnetic domain walls, is an alternative to GMI when miniaturizing the field sensor. Efficiency of GMX is studied for several nanomagnetic systems by means of micromagnetic simulations.

[1] A. Janutka, K. Brzuszek, JMMM 465 (2018) 437.
[2] A. Janutka, K. Brzuszek, J. Phys. D 52 (2019) 035003.
[3] A. Janutka, K. Brzuszek, IEEE Magn. Lett. 10 (2019) 6103105.

- Authors: J. Kisielewski, P. Gruszecki, M. Krawczyk, and A.Maziewski .

Affiliation of the presenting author:
Faculty of Physics, University of Bialystok, Bialystok, Poland

Title: *Mapping magnetic textures in films with Dzyaloshinskii-Moriya interaction.*

Abstract: Exploiting the results of micromagnetic simulations, I will demonstrate the effect of Dzyaloshinskii-Moriya interaction (DMI) on static and dynamic magnetic properties of ultrathin single films and multilayer systems. Beside a DMI magnitude, other parameters were also adjusted, like the perpendicular magnetic anisotropy (characterized by the quality factor Q) and external magnetic field. Playing with the parameters, several types of magnetic textures were observed: domains with narrow wall of either Bloch or Neel type, spin spirals, skyrmions, conical spin spirals, or in-plane magnetization configuration. Multilayer systems were also modeled with different types of nonmagnetic spacers, and different coupling between magnetic films, what led to even more interesting variety of possible magnetization states. The structures were also characterized by their magnetic susceptibility and resonant oscillations of magnetization.
Acknowledgements: Work supported by Polish National Science Center project DEC-2016/23/G/ST3/04196 Beethoven.

- Authors: Maciej Krawczyk.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Spin wave dynamics in complex magnetization textures*

Abstract: We study spin wave dynamics in thin films with perpendicular magnetic anisotropy patterned with a square lattice of antidots. We show reach spin-wave spectra at remanence which indicates the non-collinear magnetization states around the antidots. The obtained results of spin-wave dynamics in these thin films with complex, but periodic magnetization textures, allow as to point out features promising for new phenomena in magnonics and their potential usefulness for applications.

- Authors: Piotr Kuświk, Błażej Anastaziak, Łukasz Frąckowiak, Michał Matczak, Gabriel David Chaves-O'Flynn, Maciej Urbaniak, Paweł Piotr Michałowski, Arno Ehresmann, and Feliks Stobiecki .

Affiliation of the presenting author:
Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland

Title: *Local modification of magnetic properties for potential applications in magnonics*

Abstract: The development of new methods to modify magnetic properties is important in many areas. In particular, this applies to magnonics, where artificial modulation of magnetic parameters can be used to control and manipulate spin waves. Here, we present two methods for achieving such modulation. The first uses ion bombardment of ferrimagnetic layered systems; and the second, plasma oxidation of ferromagnetic layers. Both methods allow to obtain layers with periodically varied properties without topographical changes. This opens new ways to generate magnonic crystals.
This work was supported by the National Science Centre in Poland Sonata-Bis (DEC- 2015/18/E/ST3/00557) project. B. A. acknowledges support from project No. POWR.03.02.00-00-I032/16 under the European Social Fund – Operational Programme Knowledge Education Development, Axis III Higher Education for Economy and Development, Action 3.2 PhD Programme.

- Authors: Tadeusz Lulek.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Algebraic Bethe Ansatz as a tool for quantum information processing*

Abstract: Algebraic Bethe Ansatz (ABA), known as the way of expressing a unique exact result of a quantum one-dimensional N-body problem – the eigenproblem of the Heisenberg Hamiltonian for the chain of N spins 1/2 , can be also seen as a tool for various operations with systems of qubits, prepared in highly correlated multiparticle states with precisely prescribed properties. As a rule, one uses ABA in its off-diagonal version, in order to create single-magnon states with rapidities resulting from Bethe Ansatz equations – a system of r highly nonlinear algebraic equations which yields exact eigenstates of an integrable model. Here, we advocate for the diagonal version of ABA, namely for an immediate solution of (roughly) N spectral problems for constants of motion, generated from the transfer matrix – the trace of the monodromy matrix. The resulting system of constants of motion provides a realisation of a positive operator-valued measure (POVM), that is, a complete set of commuting operators along the prescripyion of Dirac. The program can be computationally realised only for a small number N of qubits, but it might be pretty practical for typical procedures carried by Alice and Bob.

- Authors: Sławomir Mamica.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Nonuniform softening of spin waves in 2D magnonic crystals*

Abstract: In thin-film bicomponent magnonic crystals (MCs) an in-plane magnetization causes the demagnetizing field to occur around interfaces between constituent materials. The field has a great impact on the spin-wave spectrum, e.g. in cobalt-permalloy MCs at the low external magnetic field the lowest-frequency spin waves are excited in Co much more likely than in Py regardless the matrix or rods are made from Co. As a consequence the nonuniform softening of spin waves takes place. We show it could be very useful mechanism to design complete magnonic gaps with different sensitivity for the tiny change of the external field.

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- Authors: S. Mieszczak, Maciej Krawczyk, Jarosław W. Kłos.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Spin wave localization on phasonic defects in magnonic quasicrystal*

Abstract: Phasons are the structural defects that are specific for quasicrystal. They are local rearrangements of the constituent elements in the quasiperiodic structure. We investigated the perturbed Fibonacci sequences of stripes with lower concentrations of phasonic defects. The goal of this study is to find the impact of the phasonic-like disorder on the spectrum and the localization of spin wave eigenmodes in magnonic quasicrystals.
The authors acknowledge the financial support of the National Science Centre Poland for Grant No. 2016/21/B/ST3/00452 and UMO-2017/24/T/ST3/00173.

- Authors: Ewelina Milińska, Sukanta Kumar Jena, Marcin Jakubowski, Aleksiej Pietruczik, Roman Minikayev, Sabina Lewińska, Artem Lynnyk, Pavlo Aleshkevych, Anuj Dhiman, Zbigniew Kurant, Iosif Sveklo, Andrzej Maziewski, Andrzej Wawro .

Affiliation of the presenting author:
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Title: *Magnetization reversal, domain structure and ferromagnetic resonance of heavy metal/ferromagnetic heterostructures*

Abstract: Inversion-Asymmetric heterostructures have been fabricated by molecular beam epitaxy (MBE) technique, in which Co magnetic layer is surrounded by Pt and W material. The W/Co/Pt and Pt/Co/W systems exhibit the high spin-orbit coupling (SOC) and iDMI (interfacial Dzyaloshinskii Moriya interaction). The labyrinth-like magnetic domains observed in as-deposited the W/Co/Pt multilayers evolve into parallel stripe domain structure (forming 1D magnonic crystals) after saturation in the magnetic field applied in the sample plane, followed by an in-plane ac demagnetization with decreasing amplitude. The average width of the labyrinth and parallel strip domains decrease with the repetition number of multilayers. Additionally, FMR and VNA-FMR spectra reveal resonance lines originating from uniform ferromagnetic precession (above saturation field) and from stripe labyrinth domain structure below the saturation field. Obtained results give insight into the dynamics properties of the samples which can be considered as MCs.
Acknowledgements: This work was supported by the EU European Regional Development Fund (REINTEGRATION 2017 OPIE 14-20).

- Authors: Daniel L Stein, Andrew D Kent, and Gabriel Chaves-O'Flynn.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Activation Barriers for Creation and Annihilation of Magnetic Droplet Solitons*

Abstract: Droplet solitons are magnetization fluctuations that preserve their shape as they precess with uniform frequency. We introduce an effective energy ξ that quantifies the work done (against damping and spin torque) to create a fluctuation of arbitrary shape Θ(ρ). We show that, for specific values of σ, some soliton solutions are saddles of ξ. This allows us to calculate thermal activation barriers Δξ between uniform precession at the ferromagnetic resonance and stable solitons. We present results of Δξ as a function of σ for a variety of nanocontact radii ρ*.

- Authors: F. Lisiecki, J. Rychły, P. Kuświk, H. Głowiński, J. W. Kłos, F. Groß, N. Träger, I. Bykova, M. Weigand, M. Zelent, E. J. Goering, G. Schütz, G. Gubbiotti, M. Krawczyk, F. Stobiecki, J. Dubowik, and J. Gräfe.

Affiliation of the presenting author:
Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland
Faculty of Physics, Adam Mickiewicz University in Poznań, Poland

Title: *1D Fibonacci magnonic quasicrystals – self-similarity of spin wave spectra, spin waves localization, and reprogrammability*

Abstract: Quasicrystals are structures that exhibit long-range order, lack translational periodicity, but possess another noteworthy symmetry property, which is self-similarity by scaling [1]. Therefore, magnonic quasicrystals surpass regular magnonic crystals regarding provided by them possibilities of spin waves control: they offer complex, self-similar spin wave spectra, localization of spin waves inside the structure, and on the surfaces of the structure [2].The results of joint collaborative research with the experimental groups will be shown, demonstrating the possibility of spin wave propagation through magnonic quasicrystal, the opening of additional mini-bandgaps [3], and the reprogrammability of the resonance frequencies, dependent on the magnetization order in magnonic quasicrystals [4]. The measurements of SWs propagating in a 1D Fibonacci sequence of dipolarly coupled permalloy nanowires are done with the help of a combined X-ray microscopic and Brillouin Light Scattering. The experimental results are interpreted using numerical calculations. Additionally, a simple model estimating frequencies of magnonic gaps in the spin wave spectra of the Fibonacci quasiperiodic structure matches the frequency mini-band gaps calculated numerically and measured experimentally. The demonstrated features of one-dimensional magnonic quasicrystals allow utilizing this class of metamaterials for magnonics and make them an ideal basis for future applications.
We would like to acknowledge the European Union's Horizon 2020 research and innovation program under the Marie Skłodowska-Curie GA Grant No. 644348 (MagIC) and NCN Poland Grant No. UMO2017/24/T/ST3/00173, No. UMO-2012/07/E/ST3/00538, and No. UMO-2016/21/B/ST3/00452, Helmholtz Zentrum Berlin/BESSY II is gratefully acknowledged for allocating beam time at the MAXYMUS end station. J.R. would like to additionally acknowledge the financial support from the Adam Mickiewicz University Foundation.

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- Authors: Piotr Rzeszut, Witold Skowroński, Sławomir Ziętek, Jakub Chęciński, Jerzy Wrona and Tomasz Stobiecki .

Affiliation of the presenting author:
AGH University of Science and Technology, Department of Electronics, 30-059 Kraków, Poland

Title: *Serially connected perpendicular magnetic tunnel junctions for multi-bit STT-MRAM storage cells and neuromorphic computing*

Abstract: One of the main limitation of the storage density of a contemporary MRAM cell is the size of the transistor capable of driving sufficiently high current density needed to switch magnetic tunnel junction (MTJ). This limitation can be overcome by using so-called multi-bit MRAM cell. We present a method of manufacturing such multi-bit cells [1] with use of serially connected standard MTJs. The device may also be used as a memristor in neuromorphic computing [2-3]. Such design is very simple to manufacture, but due to spread of parameters of MTJ some limitations are observed. Mainly an ability to distinguish adjacent resistance states is reduced as well as define voltages for writing reduces as more non-equal elements are connected. To address this issue a way to determine maximum capacity of such multi-bit cell is needed. Therefore we also propose a behavioural simulation of such multi-bit cells. We also present complete analysis of limitations of the design.
Scientific work funded from budgetary funds for science in 2017-2018, as a research project under the “Diamond Grant” program (Polish Ministry of Science and Higher Education Diamond Grant No. 0048/DIA/2017/46). This work is supported by the Polish National Center for Research and Development grant No. LIDER/467/L-6/14/NCBR/2015. T.S. acknowledges the SPINORBITRONICS grant No. 2016/23/B/ST3/01430.

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- Authors: Krzysztof Sobucki, Paweł Gruszecki, and Maciej Krawczyk.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Subwavelength control of the phase of spin waves by ferromagnetic resonators*

Abstract: Phase and amplitude are the fundamental characteristics of spin waves that can be used to carry information. We propose here a method of the modulation of the phase of reflected spin waves from the edge of a thin ferromagnetic film. Utilizing micromagnetic simulations, we demonstrate that the application of narrow resonators on top of the edges can be used to mold the phase of the reflected waves. We show that near the Fano resonances, even small change of the resonator’s geometry significantly influences the phase of the reflected waves. Noteworthy, this resonator can be treated as a magnonic counterpart of metasurface since it enables spin waves modulation, i.e., manipulation of the phase at subwavelength distances.

- Authors: Radosław Strzałka, Ireneusz Bugański, Janusz Wolny.

Affiliation of the presenting author:
Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Krakow, Poland

Title: *New approach to structural disorder in aperiodic systems – example of decagonal AlCuRh quasicrystal*

Abstract: An intriguing feature observed in modern refinements' results of quasicrystals in the log-log plot of calculated vs. observed intensities is a characteristic bias in the low-peaks regime [e.g. 1,2]. The underestimation of the calculated diffraction intensities is of an unknown origin so far. The two possible reasons are most likely: (i) improper phasonic correction conventionally used in the form of the exponential Debye-Waller factor [3], and/or (ii) multiple scattering effect [4]. In our previous studies based on the model calculations we showed that the new correction for phasons developed within the statistical approach is potentially useful to solve the problem of a bias [3]. The correction for phasons (understood as flips/rearrangement of tiles in the quasiperiodic tiling) is made at the stage of the structure factor calculation, and it assumes the fragmentation of the probability distributions of atomic positions (called also the average unit cell, AUC, which is a real-space equivalent of the atomic surface/occupation domain in the hyperspace description, more on the AUC method in [5]). The Fourier transform of the "fragmented" (influenced by phason flips) AUC gives a diffraction pattern affected by a phasonic disorder. The only parameter to fit is a flip ratio (a probability of a single tile rearrangement in the structure). We assume only two types of flips (in regions of two thin and one thick, or two thick and one thin rhombuses, which build a hexagon), the phason-phonon coupling and the secondary phason flip effects are neglected. Recently we developed also a phenomenological way of diffraction data treatment in terms of the multiple scattering effect [6]. It is based on the Rossmanith theory [7 and later works] and considers a redistribution of intensities among all diffraction peaks with a given probability (the probability parameter is to be fitted). The two corrections are included in our refinement procedure developed within the statistical method. In the presentation we will show the application of new corrections to the diffraction data (with different refinement strategies) for decagonal AlCuRh quasicrystal, originally studied by Kuczera et al. [1]. The final results are: the value of R-factor is ~6% (as compared with 7.9% in the original refinement) with phasonic ADP of 1.35Å^2, phason flip probability of 1.34%, and intensity redistribution probability of 4.2·10-7. The results were published in [6].

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- Authors: K. Szulc, M. Mruczkiewicz, P. Graczyk, G. Gubbiotti, and M. Krawczyk.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Spin-wave diode and circulator*

Abstract: We propose a model of spin-wave diode which is based on the effect of unidirectional coupling of spin waves in wide frequency range in bilayered ferromagnetic system. This effect bases on Dzyaloshinskii-Moriya interaction and dipolar coupling. Our spin-wave diode consists of ferromagnetic stripe lying above the ferromagnetic layer. Unidirectional coupling permits spin waves to transfer to the stripe when propagating in coupling direction, while in non-coupling direction the spin-wave transfer is very weak. Structure with additional layer coupled with the stripe can be proposed as a spin-wave circulator.

- Authors: Piotr Tomczak and Henryk Puszkarski.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: *Spin wave dynamics in complex magnetization textures*

Abstract: One of the main goals of performing FMR experiments is to find how the magnetic energy of a sample under investigation depends on magnetic field direction with respect to a sample crystallographic axes. This information is usually obtained by examining the experimental dependence of the resonance field value on its direction in space. The traditional analysis of experimental data is carried out using the well-known Kittel or Smit-Beljers equations describing the precessional motion of the sample magnetization. We propose [1] a new FMR data analysis method by referring to the geometric meaning of the Smit-Beljers equation: the resonance frequency of the magnetic moment precessional motion is equal to the Gaussian curvature of the spatial distribution of the magnetic free energy. This approach allows finding all the values of relevant physical quantities with high accuracy (the saturation magnetization *M*, *g*-factor, demagnetizing tensor $N_{\alpha\beta}$ *and magnetocrystalline anisotropy constants* K_{α}*) and consequently the spatial distribution of the free energy from a single set of FMR experimental data. We tested successfully [1] this approach using the cross-validation procedure [2] for bulk magnetite, (Ga, Mn). As thin film, YIG ultrathin film, Co ultrathin film and Fe thin film. Note, that it was necessary while doing the cross-validation, to use a proper form of the free energy dependence on all above mentioned magnetic parameters characterizing the sample of each ferromagnet under investigation. Therefore, the criterion of the correctness of the free energy formulas given in [2] was also applied in this work. Let us emphasize that none of the known methods of analysis of FMR experiments does give such universal opportunities.*
Acknowledgments: Supported by NCN grant No. DEC-2013/08/M/ST3/00967.

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- *Authors:* Maria Mansurova, Jakob Walowski, Henning Ulrichs and Markus Münzenberg.

Affiliation of the presenting author:
Universität Greifswald, Germany

Title: Spin-wave packats triggered by ultrashort laser pulses

Abstract: *We investigate Broadband excitations of spin-wave packets by ultrashort laser pulses at different magnonic antidot crystals and continuous magnetic film interfaces exhibit surface spin-wave modes that propagate out of the crystal into the continuous film. The propagation distance depends on the direction of the applied magnetic field as well as the surface geometry of the crystal. Additionally, Spatially resolved measurements of the magnetization dynamics on thin CoFeB films reveal that the frequencies of resulting spin-wave modes depend strongly on the distance to the pump center. This can be attributed to a laser generated temperature profile. We determine a shift of 0.5 GHz in the spin-wave frequency due to the spatial thermal profile induced by the femtosecond pump pulse that persists for up to one nanosecond.*

- *Authors:* A. Wawro, Z. Kurant, M. Tekielak, M. Jakubowski, E. Milińska, I. Sveklo, P. Mazalski, R. Böttger, A. Maziewski.

Affiliation of the presenting author:
Institute of Physics, Polish Academy of Sciences, Warsaw, Poland

Title: Spatial ion beam modifications of Co layered structures – a recipe for magnonic crystals

Abstract: *Magnetic properties of a single Co layer depend on its thickness and a type of buffer and capping film [1]. In multilayered systems magnetic configurations are more complex due to interlayer coupling depending on the nonmagnetic spacer thickness [2]. Irradiation of such structures with an ion beam substantially affects anisotropy, the coupling strength or type and even suppresses their ferromagnetic nature [3,4]. Application of a focus ion beam enables local magnetic modifications in the nanometre scale leading to 3D magnonic crystals (MC) creation. Several types of MCs are proposed for various stacks of the sample and applied fluence of the ion beam.*
Acknowledgements: This work was supported by the National Science Centre in Poland under the projects: 2014/13/B/ST5/01834 and the EU European Regional Development Fund (REINTEGRATION 2017 OPIE 14-20).

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- *Authors:* Mirosław Werwiński .

Affiliation of the presenting author:
Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland

Title: Magnetocrystalline anisotropy of $L1_0$FeNi from DFT

Abstract: *This contribution presents the results of ab initio calculations of selected magnetic parameters of the $L1_0$ FeNi phase, which are the magnetocrystalline anisotropy energies (MAEs), the full potential calculations of the anisotropy constant K_3, spin and orbital magnetic moments, and the magnetostrictive coefficient λ_{001} [1]. Furthermore, the calculated 3D **k**-resolved map of the MAE combined with the Fermi surface analysis gives a complete picture of the MAE contributions in the Brillouin zone. To increase the certainty of the result, the MAEs were calculated by using three different ab initio codes. All three codes employ the full potential and generalized gradient approximation (GGA) and give the MAEs below 0.5 MJ m^{-3}. It is expected that due to the limitations of the GGA this values are underestimated. The more reliable model including orbital polarization corrections doubles this value [2], whereas the experimental values of the anisotropy constant K1 from the literature oscillate around 1.0 MJ m^{-3} [3]. The $L1_0$ FeNi has further potential to improve its MAE by modifications, like for example tetragonal strain or alloying.*

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- *Authors:* Kacper Wrześniewski and Ireneusz Weymann.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: Quench dynamics of spin in magnetic impurity systems

Abstract: *We theoretically investigate the quench dynamics in quantum impurity systems coupled to a spinpolarized reservoir. In particular, we consider a single quantum dot system and a large-spin magnetic molecule coupled to external ferromagnetic lead. We examine the response to a quench in the spin-dependent coupling strength to ferromagnetic lead as well as in the position of the orbital level. The dynamics is analyzed by studying the time-dependent expectation values of the magnetization and spin-quadrupole moment. We predict the time-dependence of a ferromagneticcontact-induced dipolar exchange field and its nonmonotonic build-up, as well as the development of local quadrupolar exchange field. The relevant time scales describing the dynamics are identified.*

- *Authors:* Karol Załęski, Emerson Coy, Mateusz Kempiński, Hans-Peter Schönherr, João Marcelo Lopes, Jens Herfort, and Feliks Stobiecki .

Affiliation of the presenting author:
NanoBioMedical Centre, Adam Mickiewicz University, Poznań, Poland

Title: Thin films of Heusler alloy Co_2FeSi on graphene and HOPG –the candidate for highly spin-polarized injector for graphene spintronics

Abstract: *Graphene is a promising material for a spin channel in spintronic devices because of the large electron mobility and the long spin diffusion length [1]. Half-metallic Heusler alloys are the best materials for spin injectors and detectors due to the 100% spin-polarization of electrons at the Fermi level [2]. Combination of these materials can lead to the improvement of performance of the spintronic devices [3]. However, the growth of the Heusler alloys on the graphene was not studied before. Herein, we present the influence of the growth temperature on structural and magnetic properties of Co2FeSi Heusler alloys thin films deposited on: CVD graphene transferred on Si/SiO_2, epitaxial graphene on SiC and HOPG (highly oriented pyrolytic graphite – whose surface is similar to graphene). The films were grown by molecular beam epitaxy (on graphene) and by magnetron sputtering (on HOPG). In particular, the films deposited on transferred and epitaxial graphene are polycrystalline, while Co2FeSi films deposited on HOPG grow with the (001) texture. Structural and magnetic properties, and in particular the differences in the growth between the graphene and HOPG substrates will be discussed.*
This work is supported by the National Science Centre – Poland under the contract 2016/23/D/ST3/02121.

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  Affiliation of the presenting author:
  Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

  Title: Formation and driving by electric current of Neel-type skyrmion in antidot lattices

  Abstract: *Magnetic skyrmions are topologically protected nano-meter sized chiral spin textures. Due to their various unique features, such as stability given by their topology, they are considered as potential candidates for information carriers in next generation data storage devices, like racetrack memory. Therefore, it is crucial to be able to manipulate their current-induced motion. We extend the idea to control motion of skyrmion in 2D plane with the in plane electric current pulses. This goal we have achieved through the use of magnetic antidot arrays. We have demonstrated experimentally that magnetic skyrmions can stabilize in a magnetic antidot array based on Ta/Co/Pt multilayers. Moreover with micromagnetic simulations we show that in such an antidot array the skyrmions can be guided in different directions. Depending on both, the size of the antidots and the current density, different types of skyrmion motion on the film plane were found, also the one shown in figure. Thus, magnetic antidot arrays can be used as a controller for skyrmion motion by using properly designed sequences of electrical current pulses, which makes them a promising candidate for current driven skyrmion motion control.*

- *Authors:* D. Kuźma, J. Kłos, J. Rychły, S. Mieszczak, P. Sobieszczyk, and P. Zieliński.

  Affiliation of the presenting author:
  Institute of Nuclear Physics, Polish Academy of Sciences, ul. Radzikowskiego 152, 31-342 Kraków, Poland

  Title: Static configurations and spin wave dynamics in finite magnetic chains: from simplified models to micromagnetic calculations.

  Abstract: *Any defect of periodicity is a potential localization of one or several bound modes. They differ from the bulk modes in that their wave functions decay exponentially with the distance from the defect in contrast with bulk mode showing a Bloch oscillatory behavior typical of propagative waves. In this note we study possibilities of existence of end bound (edge) modes in 1d systems of macrospins of selected shapes and test validity of some simplified models in the description of the lowest frequency range dynamics in such systems. The simplest possible model by Stoner and Wohlfarth assumes the whole magnetic moment of the macrospin concentrated in one point. The dipolar interactions are, thus, very strong. The configurations of finite magnetic chains obtained with this model are very interesting in that they show a number of tilted structures as a function of a magnetic field perpendicular to the chain. More developed model involves long 1D thin threads or wires. We have found a simple analytic expression for the dipolar interactions in such threads. The latter model reproduces fairly well the lowest excitations in the finite chains of macrospins with, however, selected geometries. We will discuss the validity of the models and the best physical realization of bound states in the finite chains*

- *Authors:* M. Zdunek.

Affiliation of the presenting author:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: Interaction between thermal magnons and phonons in [Ni80Fe20/Au/Co/Au]10 multilayer

Abstract: *We have investigated surface acoustic waves' and spin waves' dispersion relations in [Ni80Fe20/Au/Co/Au]10 multilayers. The method we used in our investigations was high resolution Brillouin spectroscopy. The thickness of 0.8 nm has been chosen for cobalt (Co) layer as it exhibits in-plane effective anisotropy. It allowed us to gather spectra of spin waves for two canonical geometries. In both cases spin wave's wave vector lies in the plane of our sample, the difference occurs with the orientation of wave vector vs. static magnetization: in one geometry those vectors are perpendicular (Damon-Eschbach spin wave), while in the other they are parallel to each other (Backward Volume spin wave). The main goal of our experiment was to investigate the crossing regions of phononic ang magnonic dispersion relations.*

ABSTRACTS - posters

- Authors: Pawel Gruszecki, Konstantin Guslienko, Igor Lyubchanskii, and Maciej Krawczyk

Affiliations:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: Spin wave beam scattering at the edge spin waves

Abstract: Spin waves at certain conditions can be confined in particular regions of the sample, exemplary in a potential well created by the demagnetizing field near the film's edge. Typical frequencies of the edge-localized spin waves lay below the bottom of the spin wave spectrum. Here, we study theoretically dynamics of spin waves localized at the edge of thin permalloy film and their influence on the reflection of spin wave beams incident at the edge.

- Authors: A. Krysztofik[1], S. Özoğlu[2], E. Coy[2], J. Dubowik[1]

Affiliations:
1. Institute of Molecular Physics, Polish Academy of Sciences, Poznan, Poland
2. NanoBioMedical Centre, A. Mickiewicz University, Poznan, Poland

Title: *Damping and Magnetic Anisotropy of YIG Thin Films Deposited on Different* Substrates

Abstract: Yttrium Iron Garnet (YIG) is one of the most desirable material for spintronic and magnonic applications mainly due to the lowest achievable damping of magnetization precession. Its growth on Gadolinium Gallium Garnet (GGG) as a substrate has been well established with different deposition techniques in past few years. However, the choice of any other substrate remains challenging when the aim is not to compromise YIG damping and improve integration with current technologies. Here, we present the results of broadband ferromagnetic resonance measurements of YIG films deposited on GGG, Yttrium Aluminum Garnet (YAG) and Si substrates, as a preliminary step towards their compatibility with prevalent CMOS technology.
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- Authors: O. Busel, S. Mieszczak, P. Gruszecki, J. W. Kłos, M. Krawczyk

Affiliations:
1. Faculty of Mathematics and Physics, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Prospect Peremohy 37, Kyiv, 03056, Ukraine
2. Faculty of Physics, Adam Mickiewicz University in Poznań, ul. Uniwersytetu Poznańskiego 2, Poznań, 61-614, Poland

Title: Spin-wave phase change via resonant scattering in magnetic spacer

Abstract: An analytical theory of the spin waves (SWs) propagation through a ferromagnetic layer of finite width (spacer) in the direction of SWs propagation embedded in a ferromagnetic medium has been developed. The analytical results have been compared to the results of the micromagnetic simulations performed with the aid of Mumax3 package. Perfect agreement with the analytical results have been obtained. The resonant characteristic of the Fabry¬Perot type of transmission in the considered system has been shown. Based on the phase change of the transmitted SWs in dependence on the interface parameters the interface has been designed to obtain an anomalous refraction of SWs, namely, a device which effectively turns the direction of SWs propagation. With micromagnetic simulations it has been shown that exploiting the phase change between two neighboring resonances is sufficient to design the interface which allows for refraction of the incident SWs at any angle, keeping relatively high intensity of the transmitted wave. Our findings open the route for the design of flat metasurfaces for magnonic applications.

- Authors: Justyna Rychły, V. S. Tkachenko, J. W. Kłos, A. N. Kuchko, and M. Krawczyk

Affiliations:
Institute of Molecular Physics, Polish Academy of Sciences, Poznań,
Poland Faculty of Physics, Adam Mickiewicz University in Poznań, Poland

Title: Spin waves spectrum in ferromagnetic nanowire of cylindrical cross-section

Abstract: Nanoscale magnetic systems have been studied extensively in various geometries, such as wires of different cross sections, arrays of wires, dots, rings, etc. Such systems have promising applications in advanced magnetic devices [1]. Among them uniform magnetic nanowires are the basic structures which were investigated in the past [2,3]. However, some of their dynamical properties, like: (i) (anti)crossing between the spin wave modes and (ii) impact of magnetic field of spin wave spectrum, still need detailed studies. In our research we continue this direction and study spin wave dynamics in Ni nanowire of circular cross section. To that end we use two approaches: semi-analytical calculations and numerical calculations with the use of the finite element method. We solve Landau-Lifshitz and Maxwell equations and consider both magnetostatic and exchange interactions. We obtain spin wave dispersion relation complemented with the spatial profiles of: (i) magnetostatic potential and (ii) complex amplitudes of selected spin wave modes.
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- Author: K. Szulc[1],1 G. Gubbiotti[2], M. Mruczkiewicz[3] and M. Krawczyk[1]

Affiliations:
1. Faculty of Physics, Adam Mickiewicz University in Poznan, Uniwersytetu Poznańskiego 2, 61-614 Poznań, Poland
2. Istituto Officina dei Materiali del Consiglio Nazionale delle Ricerche (IOM-CNR), Perugia I-06123, Italy
3. Institute of Electrical Engineering, Slovak Academy of Sciences, Dubravska cesta 9, 841 04 Bratislava, Slovakia

Title: Dzyaloshinskii-Moriya interaction in bilayers with perpendicular magnetic anisotropy

Abstract: Dzyaloshinskii-Moriya interaction (DMI) is of large interest in magnonics due to its nonreciprocal character. Its stronger variant appears at the interfaces of ultrathin ferromagnetic layer with heavy metal. Additionally, in the case of these thin films also perpendicular magnetic anisotropy can play significant role and can lead to change of the spin wave propagation and even the magnetization direction. We studied experimentally multilayers composed of Pt/Co/W and Pt/Co/Ta/Co/Pt using Brillouin light scattering method and magneto-optical Kerr effect microscopy to analyze the magnetization configuration and dispersion relation. In Pt/Co/W structures with Co layer thickness under 2 nm we observe out-of-plane magnetization in the absence of the external magnetic field. Dispersion relations show linear dependences around zero wavevector with the slope resulting from DMI. In Pt/Co/Ta/Co/Pt multilayer, reversed alignment of Co/Pt bilayers leads to opposite sign of DMI parameter. Numerical analysis shows, that in all structures the spin wave frequencies are significantly decreased due to the perpendicular magnetic anisotropy and the DMI parameter reaches 1 mJ/m^2.
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- Authors: V. Babacic, J. Varghese, M. Pochylski, E. Kang, J. Gapinski, G. Fytas and B. Graczykowski

Affiliations:
1. Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland
2. NanoBioMedical Centre, Adam Mickiewicz University, ul. Umultowska 85, PL-61614 Poznan, Poland

Title: Nanoscale cold soldering of coloidal phononic crystals by high pressure

Abstract: Colloidal crystals realized by self-assembled polymer nanoparticles have prominent attraction as a platform for applications from assembling photonic and phononic crystals to organic electronics, surface coatings to drug delivery systems. In this work we report mechanical reinforcement of polystyrene colloidal crystals by means of “cold soldering” that results from nanoscale plasticization at high hydrostatic pressure of N2 and Ar. We employed Brillouin light scattering to monitor the mechanical vibrations of the crystal and thereby determine preferential conditions for soldering, i.e., formation of physical bonding among the nanoparticles while maintaining the shape and translational order of the nanoparticles.

- Autors: Mateusz Zelent

Affiliations:
Faculty of Physics, Adam Mickiewicz University, Uniwersytetu Poznańskiego 2, 61-614 Poznan, Poland

Title: Design of a spin-wave flat lens

Abstract: In this work, we show that the phase shift of the spin waves can be controlled in transmission through metasurface formed by an ultra-narrow non-magnetic spacer separating two ferromagnetic films. For this purpose, we exploit the strength of the interlayer exchange coupling interactions of Ruderman-Kittel-Kasuya-Yosida type which allows to control the phase of the transmitted spin waves in the wide range of angles [−/2;/2]. We combined the phase-shift dependency along the interface with the lens equation to demonstrate numerically the lens for spin waves based on this ultra-narrow metasurface.