KOŁO NAUKOWE
OPTYKI I FOTONIKI UW

MINI MODES PHOTONICS SCHOOL

Book of abstracts

8th-10th November 2019
Chęciny, Poland

IEEE Photonics Society
EPS
OSA The Optical Society
SPIE.
UNIVERSITY OF WARSAW
FACULTY OF PHYSICS
Rada Konsultacyjna ds. Studenckiego Ruchu Naukowego Uniwersytet Warszawski

INTRODUCTION

Dear Participants of miniModes Photonics School 2019,,
on behalf of 2019 KNOF Board and the Organising Committee I would like to welcome you on miniModes Photonics School 2019 - a new event in KNOF portfolio aimed at strengthening our community by connecting various administrative units, fostering exchange of ideas and experience as well as getting to know each other. The event is organised at University of Warsaw European Center for Geological Education between 8th and 10th of November 2019 in beautiful city of Chęciny.

We designed the program of the school to match both interests and expectation of our community and connect it tol longer program that we are implementing within general KNOF meetings. Invited talks during mniModes 2019 will be delivered by Andrzej Wysmołek (ZFCS, former FUW Dean for student affairs), Michał Karpiński (ZO, KNOF founding president), Jan Kołodyński (QOT, former KNOF treasurer). Additionally two session about translational skills will be organised. Cezary Samojłowicz (QOT) will discuss with us details of patents in optics and photonics. The second session will be run by Michał Jachura (QOT, former KNOF treasurer) who will share with us his experience on working in industry.

We would like to express our gratitude for supporting our initiatives and providing generous support to IEEE Photonics Society, European Physical Society, University of Warsaw, Faculty of Physics and Rada Konsultacyjna UW.

Looking forward to all the activities,

Piotr Węgrzyn
2019 KNOF-UW President
miniModes Organising Committee

ORGANISING COMMITTEE

Organisation of miniModes Photonics School is fully an effort of KNOF members, being UW students and PhD candidates. Contact people during the conference are marked below, together with their contact info. Those are the people you should approach with any problems and questions regarding your experience at miniModes.

- Dominika Bondar - tel. 785 099 080, dominikabondar@gmail.com
- Aleksandra Łopion - tel. 531 437 139, aleksandra.lopion@fuw.edu.pl
- Katarzyna Ludwiczak - tel. 666 490 296, katlud5@gmail.com
- Jędrzej Mijas - tel. 784 976 494, j.mijas@student.uw.edu.pl
- Piotr Węgrzyn - tel. 512 456 834, piotr.wegrzyn@student.uw.edu.pl

To make communication during miniModes Photonics School easier we created WhatsApp Group for rapid chat. You can access is by clicking here. Once entering, please keep in mind that it is a good practice to introduce yourself.

SCIENTIFIC COMMITTEE

- Czesław Radzewicz (Faculty of Physics, Univ. of Warsaw)
- Michał Karpiński (Faculty of Physics, Univ. of Warsaw)
- Jan Kołodyński (Centre for New Technologies, Univ. of Warsaw)
- Piotr Węgrzyn (Univ. of Warsaw, Institute of Physical Chemistry PAS)

2019 SPEAKERS

Jan Kołodyński

Quantum Information and Inference Lab
Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Sunday 10:00

The past and the future of quantum sensors

Acquiring and interpreting data about physical processes is vital for science and technology. Given the constant need to improve the precision of measurements, miniaturise the size of devices and increase the speed of data acquisition, *quantum sensors* seem as the way to go. Being small by definition and equipped with quantum mechanical effects by nature, they have already been shown to have the ability to beat current standards in measuring forces, acceleration, and magnetic/gravitational fields. Nonetheless, despite impressive demonstrations, their reach is still limited with simple sensing tasks being only considered so far. In my talk, I will first summarise their achievements discussing various platforms of quantum sensors (atomic, optomechanical, solid-state), in order to state the challenges currently being faced. I will show that for quantum sensors to become a real technology, they must be able to deal with dynamical signals and operate efficiently in real time despite the noise—being continuously monitored and controlled thanks to advanced tools of inference and signal processing.

J.K. acknowledges "The Centre for Quantum Optical Technologies" project (Project No. MAB/2018/4) that is carried out within the International Research Agendas Programme of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund.

Andrzej Wysmołek

Micro-Spectroscopy Laboratory
Solid State Physics Division, Faculty of Physics, UW

Saturday 15:20

Extraordinary properties of two-dimensional crystals – from graphene to transition metal dichalcogenides

In the light of the growing popularity of graphene, the attention of scientists from all around the world shifted as well to other 2D layered materials, among them transition metal dichalcogenides (TMDC) and hexagonal boron nitride. This interest is well-founded given the unique properties of these individual layered materials, which additionally feature the possibility of building LEGO-like structures made of different 2D materials, which are promising for many different applications including flexible electronics.

During the presentation I will focus on the optical and electronic properties of 2D materials including graphene, hexagonal boron nitride (h-BN) and tantalum disulfide (TaS_2). The latter material is particularly interesting due to metal-insulator transitions caused by the presence of charge density waves, which can be examined using scanning tunneling microscopy, electrical measurements as well as Raman spectroscopy.

Cezary Samojłowicz

Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Saturday 10:00, Sunday 11:40

To patent, or not to patent?

Talk will be divided into three main chapters (i) aim of patentability, and related issues, (ii) efficient patent management, how to patent and publish scientific results at the same time, (iii) patent attorney's career in a developed economy.
In the presentation it will be explained in details what is an invention and the patentable invention and state-of-the-art as an starting point for analysis in patentability of the invention. Additionally, it will be explained:

1) when is it important to file patent application and when it is useless?
2) how to read and understand claims in patents?
3) what is freedom-to-operate (FTO)?
4) difference between FTO and patentability will be explained.

Presentation will deliver an answer for question why publication and patents are not against each other and rather complementary.

C.S. acknowledges "The Centre for Quantum Optical Technologies" project (Project No. MAB/2018/4) that is carried out within the International Research Agendas Programme of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund.

Michał Jachura

Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Friday, 17:40

Encounters with optical industry in Poland: a case study

During my talk I will present a subjective overview on the job opportunities related to optical industry in Poland. Based on my personal experience I'm going to specify advantages and disadvantages of working outside academic environment.

M.J. acknowledges "The Centre for Quantum Optical Technologies" project (Project No. MAB/2018/4) that is carried out within the International Research Agendas Programme of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund.

Michał Karpiński

Quantum Photonics Laboratory
Optics Division, Faculty of Physics, UW

Friday 16:30

Title - TBA

POSTER ABSTRACTS

During the miniModes Photonics School each participant is required to present a poster summarising one of their research projects. Their abstracts are presented below.

Aleksander Bogucki

Laboratory of Ultrafast Magneto Spectroscopy
Solid State Physics Division, Faculty of Physics, UW

Ultra-long working distance spectroscopy of single nanostructures with aspherical solid immersion micro-lenses

In this work we present aspherical micro-lenses made by TPP-DLW technique which redirect emitted photons from semiconductor nanostructure into light cone of NA=0.025 - the outcoming light can be collected by 1 inch-diameter lens at the distance of 590 mm from the sample. Resulting working distance is more than 70 times longer than the one offered by conventional microscope objectives.

Dominika Bondar

Quantum Photonics Laboratory
Optics Division, Faculty of Physics, UW

High-speed camera for telecom quantum light pulses with spatial resolution mapped to the time domain.

Spatially resolved single photon detection is of great importance for multiple metrology tasks. However it is difficult to achieve, especially for infrared light, because of a lack of multipixel single-photon detectors. An entirely different approach for spatially resolved detection may be based on space-time mapping. We report our results in employing this technique for imaging of a 3D-printed sample using single photons from telecom range.

Klaudia Dilcher

Quantum Information and Inference Lab
Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Kalman filtering methods for atomic sensors

Atomic spin ensembles with optical read-out are used widely in ultra-precise sensors such as atomic clocks, gravitational wave sensors, and magnetometers. Recovering the original waveform for time varying signal is a very challenging task, and yet very desirable. In our work we simulate the output of such a sensor and, with the knowledge of the original waveform, compare the error in extraction of the original waveform from the collected data. In order to obtain best estimates of the signal, we use different Kalman Filtering techniques, also ones applicable beyond the linear-Gaussian approximation.

Jakub Dobosz

Ultracold Quantum Gases Lab
Optics Division, Faculty of Physics, UW

Towards Non-destructive Heterodyne Atom Number Measurement In An Ultracold Cesium And Potassium Mixture

Many experiments in ultracold physics rely on destructive detection, in particular absorption imaging. This limits the typical data acquisition rate to one measurement every 10-20 seconds, limited by the sample preparation time. Here, we present an alternative method of detection that exploits the phase shift induced by atoms on an off-resonance probe beam. The change in the density of the trapped atomic cloud and hence the atom number can be detected with negligible heating of the sample. The method can shorten the data acquisition time by removing the need for multiple repetitions of the experimental sequence.

Marcin Koźbiał

Quantum Information and Inference Lab
Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Utility of states with a finite number of photons in optical interferometry

The subject of the research is Bayesian phase estimation in the interferometer for various a priori phase probability distributions. Since optimal finite photon number two-mode Fock state superpositions are practically impossible to prepare in a laboratory, some more applicable states are considered, e.g. twin-Fock states. For this purpose numerical and analytical calculations of the asymptotic Bayesian measurement cost have been carried out. We show that, as long as the prior knowledge about the estimated phase is good enough, significant quantum-enhancement of precision is possible.

Julia Kucharek

Laboratory of Ultrafast MagnetoSpectroscopy
Solid State Physics Division, Faculty of Physics, UW

From MoSe2 to (Mo,Mn)Se2 – molecular beam epitaxy growth and optical analysis

Doping non-magnetic semiconductors with magnetic ions such as Mn leads to formation of diluted magnetic semiconductors. DMS exhibit enhanced magnetooptical properties and fascinating magnetic phenomena as for example carrier mediated ferromagnetism. Aim of this work is to answer if above concept can be applied to tranistion matal dichalcogenides. We have grown by MBE a series of samples in the same conditions: undoped molybdenum diselenide (MoSe2) and doped molybdenum diselenide ((Mo,Mn)Se2).We found that the addition of manganese have altered the result of photoluminescence and Raman spectra, what indicates actual incorporation of Mn ions into MoSe crystals.

Natalia Kuk

Quantum Optics Laboratory
Institute of Atomic and Molecular Sciences, Academia Sinica, Taipei, Taiwan

Electromagnetically induced transparency for application in quantum memories

Quantum memory allows for information storage in the quantum state of a system and on-demand information retrieval. It uses photons as information carriers. Realization of quantum memory requires implementation of a repeatable and highly controllable process. In this project, we use electromagnetically induced transparency (EIT) scheme in the D1 line of cold cesium atoms to perform light storage. We obtained light storage with 24% storage efficiency and further optimization of the system is required to increase it.

Sanjukta Kundu

Quantum Optics Laboratory
Optics Division, Faculty of Physics, UW

Self-referenced measurement of the spatial structure of a single photon beam

Complete characterization of spatial structure of single photons is essential for free space quantum communication and for the efficient extraction of information from light in quantum imaging. We introduce and experimentally demonstrate an interferometric technique which enables complete characterization of a 2D spatial structure of a single photon without using a known reference photon. Our technique relies on the fact that a single photon can interfere with itself. We experimentally confirm the feasibility of our technique for heralded single photons, by reconstructing their spatial phase profile. The technique can be applied to characterize arbitrary pure spatial states of single photons.

Stanisław Kurdziałek

Quantum Optics and Atomic Physics Chair
Institute of Theoretical Physics, Faculty of Physics, UW

Fundamental resolution limits in imaging of sources with fluctuating brightness

Brightness fluctuations of emitters have recently been commonly used to increase the resolution of microscopy. Super-resolution optical fluctuation imaging (SOFI) is a widely used method, which, however, lacks some theoretical basis. Our goal is to analyze this technique using the estimation theory tools such as Fisher Information and Cramér-Rao Bound. We calculate the Fisher Information associated with imaging of two fluctuating sources. It turns out, that the Fisher Information increases due to the fluctuations, so the resolution increase is indeed possible. The upper limit for an achievable resolution gain caused by utilizing the fluctuations is derived.

Paweł Kwaśny

Solid State Physics Division,
Faculty of Physics, UW

Studies of the spatial distribution of temperature of a HFET transistors using raman spectroscopy

Spatial distribution of temperature in high-power electronics is an important issue in designing new devices. To improve the overall capabilities, one must know where most of the heat is generated. One of the techniques that allows measuring the spatial distribution of heat in micro structures like HFET transistors is raman spectroscopy. In this work, change in shifts of raman peaks was used to determine the local temperature.

Adam Leszczyński

Quantum Memories Laboratory
Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Operation on spin-waves in cold rubidium quantum memory

Our atomic memory is based on cold rubidium ensemble and non-resonant Raman interface enabling converting light into spin-waves and vice versa. Using ac-Stark effect we are able to imprint arbitrary phase onto atoms. In combination with gradient of magnetic field and chirped Raman pump we created temporal equivalent of lens and free-space propagation of light. Building temporal far field imaging system we achieved spectral resolution of the order of 20 kHz.

Michał Lipka

Quantum Memories Laboratory
Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Spatial spin-wave modulation in a quantum memory

Multimode quantum memories may serve in quantum information processing and communication yet a versatile tool is required to manipulate quantum states of light held in the memory. Here we present a novel method to perform spatial phase modulation of multimode states of light held in the memory based on ac-stark effect and demonstrate its capabilities.

Katarzyna Ludwiczak

Micro-Spectroscopy Laboratory
Solid State Physics Division, Faculty of Physics, UW

Structure distortion of MnPS3 caused by spontaneous intercalation

Metal films deposited on different materials can significantly change their properties due to the intercalation process. Better understanding of this process is crucial for further research on novel 2D materials such as MnPS3. Our studies focus on second harmonic generation measurements of few-layers MnPS3 covered with aluminium. Results show distinct change of the structure of the measured material.

Aleksandra Łopion

Laboratory of Ultrafast Magneto Spectroscopy
Solid State Physics Division, Faculty of Physics, UW

ODMR studies of strain influence on dynamics of magnetic ion in quantum well

We present time resolved Optically Detected Magnetic Resonance (ODMR) studies of single (Cd,Mn)Te/(Cd,Mg)Te quantum wells. Dynamics of magnetic ions disorientation induced by pulse of microwave excitation was measured by probing photoluminescence by modulated by acousto-optic modulator short laser pulses with variable delay. The measurements were performed for series of samples of different Mg content in buffer layer which result in different strain in QW. Strain was checked by analysis of the heavy-light hole splitting of the exciton transitions obtained from reflectivity and PLE measurements.

Mateusz Mazelanik

Quantum Memories Lab
Centre for Quantum Optical Technologies, Centre of New Technologies, UW

Hong-Ou-Mandel interference of spin waves

We developed a technique that allows manipulation of material quasiparticles - spin waves in a way reminiscent of single photons. With this, we are able to realize Hanburry Brown-Twiss type measurement proving quantum statistics of spin waves stored in a quantum memory as well as two spin-wave interference, as an analog of the Hong-Ou-Mandel effect for photons. The demonstration of Hong-Ou-Mandel interference of spin-waves not only proves their bosonic nature but paves the way towards implementing complex quantum operations that are the operating principle behind the linear-optical quantum computation.

Jędrzej Mijas

Laser Spectroscopy Laboratory
Optics Division, Faculty of Physics, UW

Humidity measurements with Fast InfraRed Hygrometer

Exact humidity measurements are routinely conducted, however most of the equipment used has a slow response rate. Understanding cloud physics requires a fast-response, compact equipment for both ground-based and airborne measurements. With that aim in mind, the Fast InfraRed Hygrometer (FIRH) was designed. Utilising laser tuned to chosen H2O absorption line, it is able to perform steady measurements at the rate of several kHz. In my work, adaptation of FIRH was conducted to perform measurements at air wind tunnel facility at TROPOS in Leipzig, Germany. Confirmed validity of measurements makes FIRH suitable for helping study cloud microphysics.

Michał Mikołajczyk

Quantum Photonics Laboratory
Optics Division, Faculty of Physics, UW

Characterization of the resolving power of dispersive single photon spectrometers

Dispersive Fourier transform (DFT) devices answer to many requirements of modern spectral measurements such as high efficiency, repeatability or high resolution. We present an investigation of resolution limits of DFT spectrometers in the single-photon regime.

Katarzyna Pietrusińska
Functional Materials Laboratory
Information Optics Department, Faculty of Physics, UW

Electrochemical fabrication of porous alumina templates for plasmonic and metamaterial devices

The development of modern optical science and technology drives a constant search for novel materials with unique optical properties. The emerge of the field of metamaterials –artificial structures composed of subwavelength size elements – has allowed to bypass natural material limitations and opened completely new avenues in research. Our goal is to electrochemically fabricate porous alumina templates, which will be further used to create nanorod plasmonic metamaterials. We will demonstrate how to influence nanopores formation process to achieve desired distributions and sizes of the inclusions.

Justyna Piwowar
Kataliza i Fizykochemia Powierzchni
Faculty of Chemistry, UW

Surface vs. Bulk Properties as Investigated using X-ray Photoelectron Spectroscopy

It is well known that XPS is surface sensitive technique, which usually is used to determine surface composition. In this method, majority of registered signal is collected from ca. topmost 5 nm of the sample. This is an disadvantage, when properties of surface-top most atom layer only is to be determined. To address this issue we used a few X-ray lines of different energies to excite photoelectrons from varying depth of the sample. As a result we were able to distinguish between the bulk properties and mostly surface electronic properties as well as composition of the studied material.

Filip Sośnicki
Quantum Photonics Laboratory
Optics Division, Faculty of Physics, UW

Spectral manipulation of photon pairs by electro-optic time-lensing system

We experimentally show an optically-driven, electro-optic time lens employing a photodiode as an electronic signal source. We combine two of those achieving a stable time-lensing system, used for spectral manipulation of telecom single photons.

Piotr Węgrzyn

Physical Optics and Biophotonics
Institute of Physical Chemistry, Polish Academy of Sciences, Warsaw, Poland

Suppressing Spatial Coherence with Spatiotemporal Optical Coherence Manipulation (STOC)

We introduce and apply spatiotemporal optical coherence manipulation (STOC) technique in two different experimental configurations in full field swept source optical coherence tomography. We compare the performance of the design using we use scattering coherency matrix G and the conventional speckle contrast. Our result demonstrated that the performance of the simplified configuration based on Michelson interferometer is comparable with more challenging design based on the Mach-Zehnder geometry. A further novel finding is that the speckle suppression analysis employing G matrix is less susceptible to inhomogeneities within the image.

Adam Widomski

Quantum Photonics Laboratory
Optics Division, Faculty of Physics, UW

Generation and detection of QKD symbols encoded in time and frequency

In this work generation and detection of the Quantum Key Distribution symbols encoded in time and frequency domain was addressed. Information was encoded by means of frequency shift keying and pulse position modulation. Gaussian-shaped optical pulses were generated using electro-optic amplitude modulation creating multi-dimensional quantum states known as qudits. Four pulses were generated in both domains yielding four dimensional qudits. After attenuating to the single photon level pulses were received in the time and frequency domain. Relations between qudits and information encoded therein were measured.

Mateusz Winkowski

Laser Spectroscopy Laboratory
Optics Division, Faculty of Physics, UW

Detection of cancer markers by multi-pass laser spectroscopy in air exhaled from human lungs

The poster presents general use of laser spectroscopy for non-invasive detection of disease markers in human breath. Details of my research at Laser Spectroscopy Laboratory are also presented, including our latest advances in this field. Possibilities of cooperation for students interested in the subject who would like to participate on our work are also described.