9th WEEK OF THE YOUNG RESEARCHER

QUANTUM SCIENCE: LIGHT-MATTER INTERACTION

REPORT

Lomonosov Moscow State University
Faculty of Physics

Moscow, September 23–26, 2019

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Land der Ideen

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РОССИЙСКО-ГЕРМАНСКИЙ ГОД НАУЧНО-ОБРАЗОВАТЕЛЬНЫХ ПАРТНЕРСТВ

IMPRESSUM

Volume of the Conference
"The Ninth German-Russian Week
of the Young Researcher"

Moscow, September 23–26, 2019

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WELCOME TO THE "9TH GERMAN-RUSSIAN WEEK OF THE YOUNG RESEARCHER"!

Dear colleagues from Russia and Germany,

We are very delighted to welcome you to our Ninth Week of the Young Researcher! When we convened the "German-Russian Year of Science", in 2011, the idea was born to invite young researchers from both countries to come together to discuss current topics of mutual interest. Since then it has grown from strength to strength. The success of the first week in Kazan encouraged us to turn it into an annual event. The following years we met in Ekaterinburg, Novosibirsk, St. Petersburg and Moscow. The main goal of these meetings is to foster collaboration among young scientists and researchers who will be setting the agenda of scientific cooperation between Russia and Germany in the near future.

Research organizations and institutions of higher education of both our countries will be presenting their funding programmes and describing the platforms that they can offer to both Russian and German PhD students and Postdoctoral researchers. The overarching principle behind these presentations is to facilitate collaboration and to establish and broaden research networks. The week will illustrate how young and experienced scientists can work across borders with local authorities, associations and industry in order to develop new approaches to global challenges.

This time we discussed particular topics of interest for quantum science and technology including aspects form solid-state physics, optics, and photonics. Special emphasis was given to the challenges of the interaction of light with nano-scale solid-state systems as one of the key problems in nano-electronics and the integration of quantum devices. The organizers strove for a good mix of participants at different career stages and different fields of expertise including solid-state physics, modern photonics, optics of metamaterials, and quantum optics.

We express our deepest gratitude to the Faculty of Physics of Lomonosov Moscow State University for its academic hospitality and kind support. And, of course, we thank all of the participants, for their involvement and cooperation in this conference.

Dr Andreas Hoeschen
German Academic Exchange Service (DAAD)
Head of DAAD Office Moscow
Managing Director of DWIH Moscow

Dr Wilma Rethage
German Research Foundation (DFG)
Head of DFG Office Russia/CIS

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Professor Dr Andrey Fedyanin

Vice Rector,
Faculty of Physics, Lomonosov
Moscow State University

DEAR LADIES AND GENTLEMEN!

Today we are opening the Ninth Russian-German Week of the Young Researcher at the Faculty of Physics of Lomonosov Moscow State University. Our conference is dedicated to quantum technologies. On behalf of the University, I am very glad to welcome the respected members of the Presidium, all participants and guests of the Russian-German Week, especially those who are just starting their way in science. I think, young scientists are basically the force that moves science forward, they are the ones who will make scientific discoveries in the future. Our mission, the mission of more experienced scientists, is to help them and create all possible conditions to make their work productive.

At the opening of this event, it is necessary to say that international cooperation is extremely important for the development of science all around the world, especially if we are talking about such a rapidly developing industry as quantum science. Moscow State University cooperates with many scientific and educational organizations from different countries and Germany is one of the long-standing and most important scientific partners of MSU. So, I am very pleased to open a joint event here at the Faculty of Physics with colleagues from Germany.

During the conference, there will be reports and discussions on various topics related to quantum technologies – quantum computing and communications, solid state physics, optics, and photonics. Also, we will have a number of reports devoted to the problems of interaction of a solid state and light. Separately, I am announcing with great interest a poster section where young scientists will present their research.

I wish everyone efficient and interesting work and hope that the 9th Russian-German Week will mark the beginning of active collaborative work for the young scientists from different countries. I hope that the exchange of ideas and scientific discussions that will take place throughout the days of the event will be useful for the further development of individual scientific projects and the global quantum technology industry.

DEAR PROFESSOR FEDYANIN, DEAR PROFESSOR ALLGÖWER, DEAR DR HARMS, LADIES AND GENTLEMEN!

Beate Grzeski

Deputy Head of Mission,
German Embassy Moscow

I am pleased to welcome you to the 9th iteration of the “German-Russian Week of the Young Researcher”, which has become a cornerstone of the German-Russian science calendar.

Also this year’s “Week of the Young Researcher” will serve to develop new cooperation projects and partnerships, in particular between young scientists, thus making German-Russian science cooperation even more dynamic and intense.

In this respect, I would like to thank the German Academic Exchange Service, the German Center for Research and Innovation and the German Research Foundation and all the people who have made this event possible, for their support and contributions.

Scientific cooperation between Russia and Germany has a broad basis, ranging from exchanges of students and young scientists, partner universities, joint research institutes and research groups to cooperation within the framework of vocational training. In this vein so we work together on many concrete projects such as the European XFEL or the Arctic research expedition MOSAiC.

Because of the importance of science and education for our bilateral relations, we agreed in 2018 on a German-Russian Roadmap for Cooperation in Education, Science, Research and Innovation and launched the German-Russian Year of Higher Education Cooperation and Science 2018–2020. I encourage you to participate actively in both initiatives.

Since March 2019, more than 90 bilateral activities have been registered on the website of the Science Year. This once again underscores the intensity of cooperation between German and Russian universities.

All these activities contribute to creating a solid foundation for a substantial relationship between our two countries. The German-Russian Week of the Young Researcher is one of the finest examples for this partnership.

Since 2011, the Week of the Young Researcher has been organized annually in different cities in Russia covering various important topics. This year, the focus is set on Quantum Science, which is an integral part of the development of modern technologies.

Working together, benefiting from each other’s strengths and skills brings advantages both to Germany and Russia and keeps us competitive on a global scale. Physics is a field where Russia traditionally excels in.

I´m grateful that this year’s event is being organized at Russia’s leading university – Lomonosov Moscow State University. I would like to thank the Faculty of Physics for their kind cooperation and hospitality. I hope that the conference will contribute to an ever closer cooperation between your University and German research institutions.

May this year’s Week be successful and further contribute to the good tradition of cooperation between German and Russian scientists!

Dr Michael Harms

Director Communications, German Academic Exchange Service (DAAD) Bonn

DEAR VICE RECTOR PROFESSOR FEDYANIN, DEAR DEPUTY HEAD OF MISSION, DEAR MS. GRZESKI, DEAR VICE PRESIDENT PROFESSOR ALLGÖWER, DEAR PARTICIPANTS OF THE 9TH GERMAN-RUSSIAN WEEK OF THE YOUNG RESEARCHER,

It gives me great pleasure to welcome you all to this year's Week on behalf of the DAAD, the German Academic Exchange Service. First of all, I would like to thank very warmly our host, the Lomonosov Moscow State University. We highly appreciate the opportunity to jointly organise this outstanding German-Russian science event at Russia's leading university.

Coming together at this very special and prestigious institution is a strong manifestation of the promising development of the German-Russian relationship in science and academia. Ms Grzeski mentioned already the German-Russian Year of Higher Education and Science Partnerships and the strategic German-Russian Roadmap. We are optimistic that these joint initiatives will significantly further German-Russian cooperation in science and research.

The DAAD is delighted to be able to contribute to these ongoing endeavours – in the capacity as coordinator of the German-Russian Year and, of course, through our day-to-day work as a funding and facilitating organisation for international academic exchange and cooperation. Above all, we understand that in the end only the scientists and academics themselves can build and develop the collaboration that delivers on the demand for new scientific insights and innovation.

For this reason, all German science organisations established the German Centres for Research and Innovation (DWIH) which are strongly supported by the German Federal Foreign Office. The DAAD has taken over the management of the currently five centres worldwide. The fact that Moscow hosts one of them emphasises the huge potential we recognise in science collaboration with Russia.

With the DWIH-network, we provide a platform for a global exchange of information and ideas on partnership opportunities with the German science and innovation community. Our aim is to connect scientists, scholars, policy makers and business people across borders and facilitate a fruitful and lively dialogue. A major focus of our activities lies on exploring as to how scientists might jointly push the frontiers of knowledge and find new ways to put their knowledge to practical use. This is in many ways also what the German-Russian Week of the Young Researcher is all about.

The German Research Foundation has taken the lead again to identify a cutting-edge topic: light-matter-interaction in quantum science. Thanks to that effort and the immediate positive response of many experts in this field, we are able to welcome today 21 junior and senior scientists from German universities and research institutions. They will discuss most relevant aspects of their research with their Russian counterparts from the Moscow State University and other highly distinguished universities and research facilities from all over Russia. I am very confident that the different research angles und experiences will generate an exciting exchange of insights and approaches.

The Week is an annual flagship event of the Moscow DWIH and each of it is a topically unique one-off occasion. Nevertheless, it offers the opportunity for longer-lasting inspiration and further academic engagement. As to that, I would also like to recommend visiting the Science Café on Wednesday where the German Centre for Research and Innovation and its organisations will provide information about support and funding for German-Russian science collaboration.

I would like to thank everybody for participating, especially those of you who undertook a longer journey – and I hope that all of you will enjoy and make the most of the Week!

LADIES AND GENTLEMEN, DEAR PARTICIPANTS,

Professor Dr Frank Allgöwer

Vice President of the German Research Foundation DFG

Institute for Systems Theory and Automatic Control, University of Stuttgart

We were very pleased that you have accepted the invitation of the joint initiative of DAAD, the German Academic Exchange Service, and DFG, the Deutsche Forschungsgemeinschaft, under the roof of the German Centre for Research and Innovation in Moscow, as well as the Moscow State University and the Quantum Technologies Centre. Our DFG delegation was more than happy to have welcomed you to the 9th Week of the Young Researcher in Moscow!

After being focused on issues of energy, health, aerospace, history, mathematics, urban studies and biomedicine, as well as chemistry over the last nine years, this year's topic encompasses various aspects of quantum science and technology including solid-state physics, optics of metamaterials, modern photonics, and quantum optics. Special emphasis will be given to the challenges of the interaction of light with nano-scale solid-state systems as one of the key problems in nano-electronics and the integration of quantum devices.

Taking into account the growing population and rising living standards, the world is faced with an increasing demand of power consumption, data storing and communication. Modern technologies rely on devices with cleverly designed electronic and optical properties. Finding new functionalities in quantum science, for example, for sensors, information storage and processing, cryptography, or metrology, requires fundamental understanding at the quantum level. The decreasing size of basic circuits in modern micro- and nano-electronics leads to the necessity to consider quantum effects and to apply quantum science approaches for the careful analysis of their properties. Experimental studies with ultrahigh resolution in space and time and advanced theoretical descriptions are mandatory. In this sense, one of the most important issues in modern quantum science is the interaction of optical fields with micro- and nanoscale solid-state circuits. The ability to manipulate these circuits by light will have amazing possibilities for studying fundamental questions as well as applications. Examples are the generation of spin-polarized states in semiconductor nanostructures, the precise manipulation of micro- and nanoparticles, and the non-trivial susceptibility of metastructures. In the future, quantum science and technologies should lead to practically significant scientific and technical results in the areas of spintronics, photonics, metamaterials, quantum optics, quantum computing and quantum communications.

There is no doubt that this broad range of research questions is of high interest to many researchers worldwide. The DFG with its annual budget of more than 3 billion euros finances and supports a large number of interdisciplinary projects in this field of research at German universities and

research institutes with funding instruments ranging from individual grants to coordinated long-term programmes such as Research Training Groups (Graduiertenkollegs) or Collaborative Research Centres (Sonderforschungsbereiche).

When it comes to the German-Russian cooperation, physics profits tremendously from the annual bilateral DFG calls with the Russian Foundation for Basic Research (RFBR) and the Russian Science Foundation (RSF). Those thematically open calls foster long-term cooperation in physics between Russian and German scientists. Russia still is and will stay one of the most important cooperation partners for us in physical sciences.

Apart from the topical aspects of this week, allow me to point out that this year's research week is deeply embedded into our German-Russian partnership in many ways.

First of all, it is an important event of the ongoing German-Russian Year of Higher Education Cooperation and Science 2018-2020. In fact, the programme itself was incepted nine years ago during the German-Russian Year of Science in 2011/2012, which led to an annual event since then. We intended to provide early career researchers with a platform for exchange on research topics of global interest. Also, the format itself follows a very old tradition in our bilateral collaboration. Namely, in the 1920s, the DFG's predecessor organisation, together with the Soviet Academy of Sciences, organised joint science weeks. These bilateral research weeks, which were conducted in the natural sciences (1927), in history (1928), in engineering sciences (1929), and in medical sciences (1932) proved to be an outstanding cooperative instrument.

Second, we owe our gratitude to the Lomonosov University and its Rector, Mr Sadovnichy, and the Faculty of Physics with its Vice-Rector Mr Fedyanin, in particular for setting up and hosting this event and thus giving young scientists the opportunity to directly engage in such a professional exchange. In October 2018, the DFG-President Peter Strohschneider and Rector Sadovnichy signed a joined agreement on intensifying our bilateral institutional cooperation. We consider this year's week to be an important step towards this goal. Yet, project-wise the DFG has always been active in supporting research projects – about 113 bilateral cooperation projects at the MSU (30 of them co-funded by RFBR and 10 by RSF) in the period from 2008 to 2018, which is more than at any other Russian research institution. The two largest German-Russian long-term projects at MSU were two International Research Training Groups from the life sciences with the universities of Gießen and Marburg (GRK 1384, 2006-2015) and the Munich universities LMU and TUM (GRK 1563, 2009-2013). In addition to the life sciences, projects in soil and plant sciences, in mathematics and astrophysics, in experimental and theoretical physics as well as in polymer chemistry and process engineering were funded.

Finally, I would like to thank the German Embassy, always represented at the weeks by their ambassadors or their deputies, for the continuing support of this format. You have long recognised that these scientific meetings foster research cooperation and make a valuable contribution to developing trust and partnerships among the early career researchers and future generations of scientists from both our countries.

WHAT WILL WE BE TALKING ABOUT: LIGHT-MATTER INTERACTION

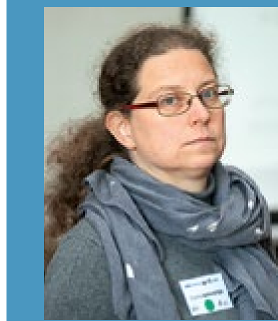
Taking into account the rising living standards, the world is faced with an increasing demand for less power consuming data storage and communication techniques. Modern technologies rely on cleverly designed materials and their electronic and optical properties. The decreasing size of basic circuits in modern electronics leads to the necessity of considering quantum effects for their further improvement. Finding new functionalities, for example, for information processing, ultrasensitive sensors, inherently secure communication and cryptography, or precision metrology, requires an understanding and the access to the quantum-mechanical level. Since the beginning of the 20th century, quantum mechanics forms the theoretical basis for our understanding of the microscopic world. At the core of modern quantum science, there is the notion of entanglement, a feature without a classical analogue. For example, properties of entangled particles are perfectly correlated even if there is a large distance between them. This correlation is responsible for astonishing phenomena. For further developments, experimental studies providing ultrahigh resolution on the atomic scale and advanced theoretical descriptions are mandatory. Yet, individual demonstrators of quantum devices have been already built with semiconducting, superconducting, ionic and cold atom systems.

As light is often used as a tool, the interaction of optical fields with matter is intensively studied in current quantum science. An example for intriguing cooperative behavior based on quantum effects is superradiance, where the collective response of an ensemble of emitters irradiated with light is fundamentally different from the scattering properties of individual particles. Light-matter interaction plays also an important role in a wide range of different quantum systems, from the trapping and precise manipulation of atoms and nanoparticles, the generation of spin-polarized states in semiconductor nanostructures, and the shaping of light by metamaterials or metasurfaces. In addition, ultrafast laser pulses with intense laser fields provide a unique opportunity to study and to manipulate solid-state systems.

A distinctive feature of modern science about the interaction of light with matter is the fact that both light and matter are considered at the level of individual quantum objects. This is, perhaps, the main difference between the physics of the 20th and the current centuries. Enormous successes, first of all, in the technology and equipment available in the modern experiment, enable scientists to study and control the properties of individual quantum particles – photons, atoms, ions, molecules, etc. These opportunities are widely used by the successes of modern physics of the interaction of light with matter in such areas as quantum computing, quantum communication, and quantum sensorics – in everything that we know as "Quantum Technology".

Quantum properties of light are prominent in single photon sources which are necessary for the realization of quantum repeaters. Trapped ions and single molecules like pentacene can be used as sources of single photons; but also colour centers created by nitrogen vacancies in diamond or semiconductor quantum dots are widely investigated in this context. Pairs of single photons are created in spontaneous parametric down-conversion and spontaneous four-wave mixing. They are essential for quantum key distribution, a cryptography protocol using quantum mechanics, which is already commercially available.

All in all, light-matter interaction is the key ingredient in implementing quantum devices and applications. Modern quantum science continues to be a very active field, in particular, where quantum optics and solid-state physics are merging.



Dr Cosima Schuster
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PARTICIPANTS OF THE WEEK OF THE YOUNG RESEARCHER

Professor Dr Mario Agio
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Ultrafast Coupling of Light with Quantum Emitters

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The modification of light-matter interaction by metal nanostructures has gained a considerable attention across a broad range of topics [1]. Our interests focus on the interrogation of single quantum emitters, where we have shown that huge enhancements of the spontaneous emission rate can coexist with large quantum efficiencies [2]. This makes such hybrid systems appealing for exploring ultrafast quantum phenomena on the nanoscale and for developing quantum technologies. We discuss configurations that strongly increase light-matter interaction and address quantum coherence and nonlinear optical processes that occur despite the existence of large dephasing rates. Next, we propose approaches that combine these findings with ultrafast techniques in order to enable the investigation of short-lived coherence and quantum effects in nanoscopic systems under ambient conditions [3,4].

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Nonlinear Polarimetry with Parametric Down-Conversion

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Polarization is arguably the most accessible degree of freedom of light fields [1]. Using readily available polarizers of various kinds, a beam of light is easily polarized and analyzed. A pair of polarizers forms a polarimeter, which permits measurements of light field rotations induced by various physical processes with great precision. Ever since Malus' original studies on polarization in the early 19th century, polarizers are almost exclusively made of linear optical media. Though secondary to their primary role as frequency converters [2], nonlinear optical processes also polarize light fields. Intuitively, one expects the nonlinearities to promote quantitative advantages such as improved degree of polarization [3]. The difference between linear and nonlinear polarizers is more profound, however, and fundamentally changes the operating principle of a polarimeter. Here we discuss this principle and demonstrate a polarimeter that consists entirely of nonlinear polarizers. Our first experimental results using parametric down-conversion indicate extinction ratios many orders of magnitude better than available with linear optical polarizers.

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Generation of Time-Bin Qudit Based on Spontaneous Parametric Down-Conversion

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Single photons are actively used as information carriers in applications of quantum optics and quantum informatics. One of their main properties is the inability to read information without destroying the quantum state. The use of multidimensional entangled states can increase the information capacity [1]. In addition, high-dimensional states are resistant to eavesdropping attack in the quantum key distribution protocols [2] and a strong violation of the generalized Bell inequalities [3] with possible applications in device-independent quantum cryptography [4] and random number generation. In our work, we consider the possibility of generating high-dimensional states based on time coding via spontaneous parametric down-conversion.

In our work, we used a lithium niobate crystal doped of magnesium oxide $LiNbO_3$: MgO (5%) (PPLN), the modulation period of which is Λ = 7.47 μm and the length is 25 mm. At a pump wavelength of 532 nm, photon pairs are generated at wavelengths of 867 nm and 1377 nm during the 0-type synchronism SPR (eee type) at the temperature of 85 degrees Celsius. As a result, photons $\Delta\nu_{mod}$ = 73 MHz at a wavelength of 867 nm were obtained [5]. For generation of time-bin qubits we used scheme presented in [6]. First results of this study will be presented at the poster.

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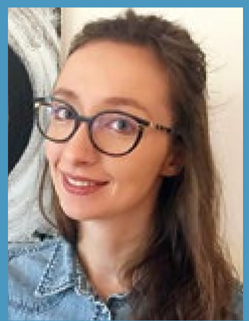

Susanne Candussio

University of Regensburg, Terahertz Centre

Terahertz Radiation Induced Edge Currents in Graphene in the Quantum Hall Regime

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We report on the observation of terahertz (THz) radiation induced chiral edge currents in graphene in the quantum Hall regime (QHE) [1]. In this regime the direction of the edge photocurrent is dictated by the polarity of the external magnetic field while its magnitude depends on the radiation polarization. Importantly, the current flows in the same direction for electrons and holes, as confirmed by experiments with variation of back gate voltage. The overall behaviour of the edge photocurrent, therefore, is qualitatively different from the edge photocurrent excited at zero magnetic field [2,3] where the current direction is opposite for electron and holes and can be changed by variation of the radiation polarization.

The used radiation has photon energies smaller than the cyclotron gap, and therefore, induces indirect transitions within the chiral edge channel. We demonstrate that the edge current is generated by Drude-like transitions within this channels resulting in a net velocity of the charge carriers. The developed microscopic theory describes well the experimental data.

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Generation of Entangled Photons without Momentum Conservation

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Dr Maria Chekhova

Max-Planck Institute for the Science of Light, Erlangen;

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Spontaneous parametric down-conversion (SPDC) is a convenient source of entangled photons. Due to its relatively low efficiency, up to now it has only been used under the condition of phase matching. In this case, the momentum of the pump photon is conserved by the daughter entangled photons. At the same time, the necessity to satisfy the phase matching restricts the choice of available nonlinear materials.

In this work, by using a 6.8 micrometre layer of lithium niobate crystal in the geometry where its strongest nonlinear tensor component was fully used, we observed SPDC without phase matching. The longitudinal momentum conservation could be relaxed due to the small thickness of the nonlinear layer. Under pumping with 170 mW of continuous-wave radiation at 500 nm, we have registered about 1 kHz flux of photon pairs collected into single-mode fibre [1].

The new SPDC source has extremely broad wavelength and angular spectra (about an octave in wavelength and about 30° in angle). This broad spectrum is a result of the relaxed longitudinal momentum conservation. Meanwhile, transverse momentum and energy are strictly conserved, which leads to tight correlations of photons in angle/space and frequency/time. This, in its turn, leads to an extremely high continuous-variable entanglement of the produced two-photon state.

In a series of experiments, we have demonstrated a high rate of entangled pairs, a spectrum 200 nm broad, limited only by the bandwidth of the equipment used, and a high degree of frequency and angular entanglement. The latter was tested through stimulated-emission tomography (SET) [2]. In one of the experiments, angular-space SET was performed, to the best of our knowledge for the first time.

The new source can be optimized by passing to materials with even higher nonlinearity: for example, GaAs or other semiconductors. The thickness of the material can then be reduced to the nanoscale, without a large reduction in the rate of coincidences. Further developments can be integration into optical chips and nanostructuring of the nonlinear material.

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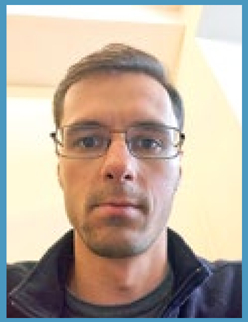

Dr Mikhail Durnev
Ioffe Institute, St. Petersburg

Photoinduced Edge Current in Systems with Two-Dimensional Electron Gas

Two-dimensional (2D) crystalline materials have been in focus of scientific research since the discovery of graphene monolayers [1]. Since then the class of 2D materials has significantly expanded and now includes monolayers of transition metal dichalcogenides [2], hexagonal boron nitride [3], layered semiconductors, such as GaSe, GaTe [4], and many more. One can even combine those 2D layers in stacks forming the so-called van der Waals heterostructures [5]. The position of Fermi level in 2D materials can be controlled in experiment by changing the voltage on a gate electrode. In the case when Fermi level lies in the conduction (or valence) band, the 2D gas of free charge carriers (electrons or holes) is formed within the layer. This gas controls electronic, optical and thermal properties of the system and thus its study is of importance for both fundamental and applied science. In this talk, I will present theoretical study of an optoelectronic phenomenon, namely, the emergence of direct electric current upon illumination of the edge of 2D crystal with electro-magnetic wave. Such photoinduced edge current was observed in graphene in [6], however the detailed microscopic theory has not yet been developed. I will discuss possible mechanisms of the photocurrent generation in classical and quantum regimes, the role of edge properties and external magnetic field directed perpendicularly to the layer. I will present results of theoretical calculations and compare it to recent experiments.

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Realizing 3D Random Walks of Correlated Photon Pairs

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Quantum Walks (QWs) provide a bright field of application from modelling quantum processes to quantum search algorithms and quantum computation. In order to study quantum interference, quantum walks for indistinguishable photon pairs have been implemented in one- and two-dimensional waveguide lattices [1,2]. Two-dimensional quantum walks have demonstrated features that cannot be achieved in planar lattices [3]. Taking this feature as motivation, our aim is to promote the understanding of QWs for correlated photons on three-dimensional lattices with the vision to establish a basis for new, on-chip quantum simulation and computing applications.

The direct femtosecond laser-writing technique is a promising route to nearest neighbor-coupled geometries of waveguides for QWs in one and two dimensions [4]. This writing technique creates birefringent waveguide [5] with a controllable optical axis orientation [6,7]. Hence, direct laser-written waveguides provide a full polarization control.

In our work, we show the equivalence of coupling behavior between two waveguides and orthogonal polarization direction in a birefringent waveguide. We use the polarization and its afore mentioned features to extend a two-dimensional waveguide lattice by the third dimension. We observe correlations of photon pairs unveiling Hong-Ou-Mandel interference as well as phenomena unique to these structures.

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Towards Spontaneous Parametric Down-Conversion in Lithium Niobate Metasurfaces

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Lithium niobate (LN), a birefringent crystal, is an attractive material for nonlinear photonics due to its wide transparency range and high second-order nonlinearity. Among other applications, it has been used for fabrication of fast optical modulators and nonlinear frequency converters. However, almost all implementations to date were using bulk LN crystals or waveguides. Although isolated Mie-type nanoresonators in lithium niobate have been shown very recently [1], functional metasurfaces [2,3] based on densely packed arrangements of such nanoresonators have not yet been demonstrated. The key feature of these metasurfaces, the resonant enhancement of local fields, may allow to boost nonlinear effects such as second-harmonic generation and spontaneous parametric down-conversion (SPDC), thus offering interesting opportunities for the efficient generation of pairs of entangled photons.

In this work, we have designed, fabricated and experimentally investigated nonlinear metasurfaces consisting of an array of LN nanocubes featuring Mie-type resonances at the telecom wavelengths. Prior to performing quantum experiments, we characterized second-harmonic generation (SHG) from the metasurfaces. Firstly, in the optical transmittance spectra, we observed electric dipole and magnetic dipole Mie-type resonances in the vicinity of a target wavelength 1550 nm. Numerical simulations confirmed the nature of resonances. Secondly, we carried out SHG measurements in transmission, which demonstrated strong SHG signal when exciting at 1550 nm with a pulsed laser. At the back-focal plane of the collecting objective, the 0th and 1st diffraction orders can be seen corresponding to the period of the metasurface.

With these results, we show that resonant metasurface based on lithium niobate is a suitable platform for second-harmonic generation. Due to the principle of quantum-classical correspondence, one can expect efficient spontaneous parametric down-conversion from this sample. Therefore, our next goal is studying the quantum behavior of the fabricated metasurfaces.

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Nonlinear and Tunable All-Dielectric Metasurfaces

The use of the optically induced Mie resonances in all-dielectric nanostructures – metasurfaces allows us to reveal new physical effects which can be used in many prospective applications from tunable antennas and flat optical devices to ultra-sensitive sensors and active nanophotonic components. In this talk, we discuss various optical effects in all-dielectric structures composed of Mie resonant nanoparticles upon their interaction with femtosecond laser pulses. We consider nonlinear-optical effects based on quadratic and cubic nonlinearities of resonant dielectric nanostructures involving light localization in electric and magnetic dipolar resonances. Special attention is addressed to nanoparticle oligomers consisting of several, up to four, nanoparticles having collective resonances. Then, we discuss ultrafast tunability and all-optical switching in subwavelength nonlinear dielectric nanostructures exhibiting localized magnetic Mie resonances. The results are compared with optical switching based on Bloch surface waves and optical Tamm states in one-dimensional photonic crystals, and creation of a new low-loss active nanophotonic devices is discussed.

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Multimode Four-Photon Hong-Ou-Mandel Interference

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The conventional two-photon Hong-Ou-Mandel (HOM) interference plays an important role in testifying the degree of indistinguishability of photons. Recently, multiphoton quantum interference is in focus of research since it is a crucial ingredient of boson samplings and a promising tool for a high dimensional entanglement [1]. In this research we investigate both theoretically and experimentally the properties of the four-photon HOM interference.

We consider four photons generated in the type-II PDC process in a KTP waveguide. Dispersion properties of KTP allow engineering a single Schmidt mode source as well as a multimode source by changing the pulse duration or by chirping the pump pulse [2]. The type-II PDC source creates two photon pairs having two orthogonal polarization which were split up in two arms of an interferometer by a polarization beam splitter. By making them have the same polarization, we let them interfere on a beam splitter and finally they were detected.

The theoretical simulations and the experimental results coincide and show that via increasing the number of Schmidt modes, an antibunching peak appears. Furthermore, the relation between the number of Schmidt modes and the antibunching behaviour is confirmed by using the chirped pump pulse [3]. By fixing the spectral width and varying the spectral quadratic phase (chirp) of the pump laser, the PDC state with the chirped pulse is characterized by the same signal-idler spectrum as in the single-mode regime but completely different mode structure.

In conclusion, it was shown that it is possible to control the interference pattern, coherent length of photons and bunching properties of the four-photon HOM interference by modifying the number of Schmidt modes.

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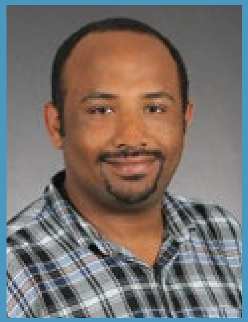

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Plasmon-Assisted Ultrafast Photodynamics in Quantum Dots

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Colloidal quantum dots (QDs) represent a promising nanoscale material for application in optoelectronics, photovoltaics and in the life sciences. Limitations like fluorescence blinking, Auger process and surface traps are commonly addressed by growing a wide-bandgap shell. However, the shell isolates the excitonic wave function and reduces its interaction with the external environment necessary for different applications. In addition, the long fluorescence lifetime hinders their application in high-speed optoelectronics.

We demonstrate a high degree of control on the emission dynamics of a bare core CdTe quantum dot by plasmon coupling to gold nanocones. We show that surface defect state emission and Auger processes from a trap-rich quantum dot can be significantly quenched by enhancing the band-edge state emission rate by more than three orders of magnitude. Increasing the quantum efficiency of the excitonic transitions turns the defect-rich bare QD into a bright photon source, with implications for nanoscale lasers, light emitting devices, solar cells and ultrafast single-photon sources. The approach can also be used to shape the emission spectrum and for achieving strong coupling at room temperature.

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Light Scattering by Lattices of Resonant Nanoparticles in Dipole Approximation

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Rigorous coupled-wave analysis (RCWA) is a very effective tool for studying optical properties of multilayered vertically invariant periodic structures. However, it fails to deal with arrays of small particles because of high gradients in a local field. In our paper [1], we implement discrete dipole approximation (DDA) for the construction of scattering matrices of arrays of resonant nanoparticles. This strongly speeds up the calculations and therefore provides an opportunity for thorough consideration of various layered structures with small periodic inclusions in terms of the RCWA. We study in detail three main stages of the method: calculation of polarizability tensor of a single nanoparticle, effective polarizability of this particle in a lattice and corresponding scattering matrix of the layer for further integration in the conventional RCWA approach.

We demonstrate the performance of the proposed method by considering plasmonic lattices embedded in a homogeneous ambiance and placed inside and onto optical waveguides, and compare our results with experimental papers. Such phenomena as localized surface plasmon resonances (LSPRs) and lattice plasmon resonances (LPRs) are observed as well as their hybridization with photonic guided modes. High accuracy and fast convergence of our approach are shown by a comparison with other computational approaches. Typical limits of applicability of our approximate method are determined by an exploration of the dependence of its error on the parameters of the structure.

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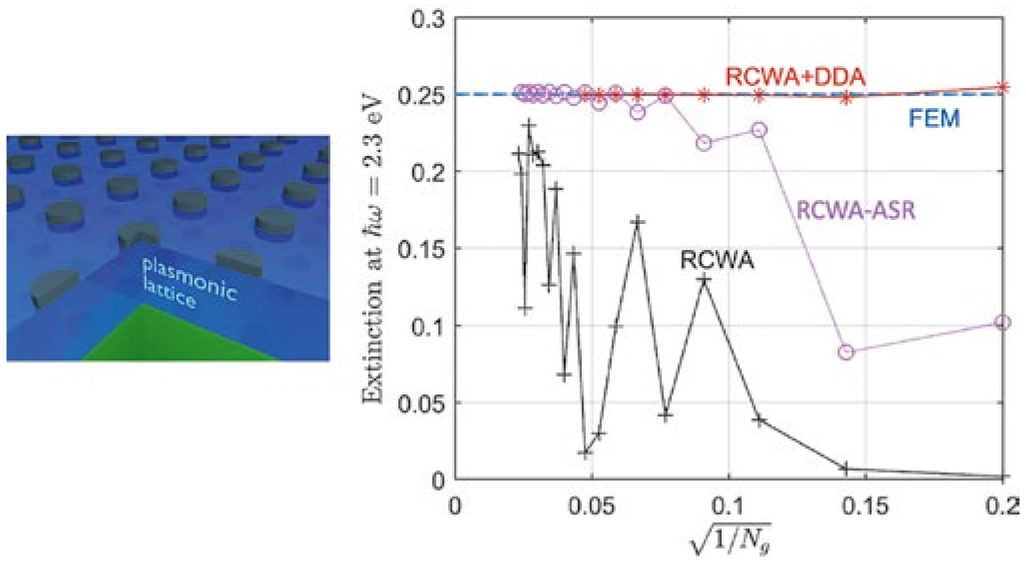

Fig. 1. Extinction of the gold nanoparticle lattice in bulk silica for a normally incident light calculated by different methods as a function of total number of Fourier harmonics. The proposed approach (1) converges even faster than conventional Fourier modal method enhanced by adaptive spatial resolution (RCWA-ASR) and provides precise results.

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Terahertz Probing of Electron States in 3d Topological Insulator Materials

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Optoelectronic probing in terahertz spectral range is a powerful tool that may provide us with information on electron dynamics in different type of materials, in particular, in topological insulators featured by non-trivial surface electron states formation [1]. In this paper, we present our results on terahertz radiation induced photoelectric phenomena in Bi_2Se_3- and HgTe-based 3D topological materials in close vicinity to the topological phase transition point. Taking into account the difference between these two materials in Fermi level location with respect to the band edge, we take an approach that best suits for each specific system of the mentioned above.

We study photoelectromagnetic effect excited by terahertz radiation and magnetic field in Bi_2Se_3-In_2Se_3 solid solutions, which demonstrate composition-driven transition between topological and trivial states. High bulk carrier concentration in combination with the low energy of the incident quantum lead to the diffusive fluxes defined by the mobility gradient between the surface and the bulk carriers. We show that the surface carrier mobility exceeds the mobility of the bulk carriers [2]. We find the specific features of electron energy relaxation in Bi_2Se_3 topological insulator.

In contrast, $Hg_{1-x}Cd_xTe$ structures are characterized by rather low bulk carrier concentration values. Another important feature of these objects is a zero band gap in composition range x<0.16. In this situation, we observe terahertz photoconductivity. We show that the photoconductivity changes both its sign and kinetics across the transition from the topological to the trivial state [3]. We provide arguments for edge non-equilibrium transport channel formation in magnetic field in $Hg_{1-x}Cd_xTe$ topological phase.

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Optical Metasurfaces and Integral Photonic Structures for Control of Nonclassical Light on Subwave-Scale

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The work is devoted to the creation and study of flat and integral optical nanostructures that can control non-classical quantum radiation at microscales. Within this research, special attention is paid to the introduction of flat dielectric meta-surfaces for tomography of orbital-angular pulses and the creation of integrated optical elements, such as multiplexers, optical developers and waveguides, which can effectively manipulate non-classical radiation using the two-photon lithography method. The results obtained can be applied in quantum cryptography to increase the degree of protection and security of broadband communication channels and information processing.

Far and Mid IR Stimulated Emission in HgCdTe Quantum Well Heterostructures

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Far IR range still lacks compact and efficient radiation sources. Quantum cascade lasers (QCLs) demonstrate remarkable performance in the range 1–5 THz and above 15 THz. In between 5 and 15 THz, their characteristics drop because of phonon absorption. The interband lasers based on HgCdTe quantum wells (QWs) are a straightforward alternative since in this system the nonradiative Auger recombination can be suppressed due to a symmetry" of electron and hole dispersion [1].

Structures under study were designed so as to confine light to in-plane direction, therefore the "active" region (5–11 QWs) was placed at the antinode position of TE0 mode of the dielectric waveguide [1]. The samples were mounted either on the cold finger of a closed-cycle helium cryostat (T = 8-200 K) or in a Peltier cooler (T = 200–300 K). The light was collected from the sample's facet [1,2].

In the long wavelength range the best results were achieved at a "cold" excitation with pulsed (100 ns) CO_2 laser (λ = 10.6 μm), and SE was obtained at a record wavelength 31 μm (9.7 THz) where the existing QCLs do not operate. At shorter wavelengths λ ~ 10 μm the excitation threshold power (λ_{exc} ~ 2 μm) proved to be as low as 120 W/cm^2 [1] and the SE has been obtained even at CW excitation.

In narrow (1.5–2 nm) HgTe/CdHgTe QWs, the SE was obtained in 2.8–3.5 μm at temperatures available with thermoelectric cooling [2], making such lasers of interest for spectroscopy applications in the atmospheric transparency window 3–5 μm.

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Quantum Metamaterials Composed of Superconducting Flux Qubits

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We propose a single photon detector based on superconducting quantum metamaterials. The main idea here is to exploit the entangling interaction of the incoming photon with the quantum metamaterial sensor array [1]. The interaction produces a spatially correlated quantum state of the sensor array, characterized by a collective observable (e.g., total magnetic moment), which is read out using a quantum non-demolition measurement. We demonstrate that the effects of local noise are suppressed relative to the signal from the spatially coherent field of the incoming photon as $1/\sqrt{N}$, where N is the number of array elements.

One of the key issues for the realisation of this protocol is to demonstrate the existence of collective modes corresponding to coherent oscillations of the meta-atoms. In the first set of experiments, 20 meta-atoms, in our implementation so-called flux qubits, are embedded into a microwave resonator. A collective mode for interaction with the cavity field was experimentally demonstrated [2].

In a second set of experiments, the transmission of a microwave signal through a metamaterial based on double-loop flux qubits has been studied [3]. We observed the periodical dependence of the transmission on the applied magnetic field. A field-controlled change of the ground state configuration of the meta-atoms induces a suppression of the transmission. Additionally, an excitation of meta-atoms leads to resonant enhancement of the transmission.

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Racing to Triplet States The Fibres are under Pressure

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Here, we present three different fibres schemes targeting the generation of efficient third harmonic so as to identify by this way the most suitable platform for the generation of photon triplet states. The creation of triplet photon states, which can be regarded as the reverse process of the generation of third harmonic requires to fulfill the same phase-matching conditions. At first, we focus on gas-filled hollow-core photonics crystal fibres. These fibres allow the propagation of the light in the hollow central region of the fibre in a diffractionless manner. Here, we used a 38 µm core diameter AR-PCF consisting of 12 non-touching capillaries (Fig. 3b) and filled the fibre with 9.2 bar of Xenon. We demonstrated the THG from 1600 nm in the fundamental mode into several high-order modes around 532 nm by adjusting the filling gas-pressure. In an alternative approach aiming to increase the overlap between the modes of the pump and the generated third harmonic, we designed and fabricated a totally new hybrid fibre. The core of the fibre consists in a microstructured arrangement of glasses with low (LFF1 Schott glass) and high (SF6 Schott glass) refractive indices allowing the guidance of the visible wavelength by solid-bandgap effect [1]. This core is surrounding by large air-channels ensuring the guidance by total internal reflection of the IR. These two guidances mechanism ensure intra-modal phase-matched THG. In the last scheme we propose to use tapered optical fibres. The stringent fabrication tolerances are mitigated by embedded the taper inside a gas-cell so as to allow the tuning of the phase-matching conditions, and by this means the tuning of the generated third harmonic [2].

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Single Photons from Photonic Molecules

Developing integrated sources of single-photon and entangled two-photon states of light is an important task of quantum optics and optical quantum technologies. In particular, preparing single-photon states via nonlinear optical effects in microring resonators is a forward-looking approach to develop compact and effective on-chip devices that are compatible with existing CMOS technology.

In doing so, a system of coupled microring resonators, which is often referred to as a photonic molecule, has proved to be a promising structure for creating effective quantum light sources and controlling basic properties of the generated quantum states. In this talk, I will give an overview of the recent progress in this field and describe some viable schemes of such single-photon and two-photon sources.

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Photoinduced Nonlocal Electron Transport in HgCdTe Solid Solutions with Inverted Energy Band Order

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Topological insulators (TI) are featured by high-mobility conductive surface (or edge) states formation and are of great interest [1]. Demonstration of topological states existence was done by the angle resolved photoemission spectroscopy (ARPES) [2]. However, ARPES technique does not provide any information related to electron transport via these states. Experimental manifestation of the topological states in electron transport is a quite relevant problem. An application of direct transport measurement techniques and optoelectronic approaches is still quite challenging for most of TIs due to high bulk carrier concentration.

MBE grown $Hg_{1-x}Cd_xTe$ epitaxial layers are considered as a distinctive example of realisation of topological phase with relatively low bulk carrier density. $Hg_{1-x}Cd_xTe$ ternary alloys are characterized by inverted energy spectrum in composition range x<0.16 and normal band structure at x>0.16 thus demonstrating a topological phase transition. The energy spectrum modification is followed by qualitative changes in photoelectric phenomena [3].

In this work, we demonstrate our results on a terahertz photoconductivity in $Hg_xCd_{1-x}Te$ thick epitaxial films with an inverted energy spectrum. Our experimental approach includes measurements in so-called nonlocal geometry of the sample coupling that provides us an opportunity to vary bulk transport contribution to the net photoresponse. We reveal the nonlocal component in the net response that indicates an additional transport channel formation. Behavior of the photoresponse in magnetic field indicates the chirality of the channel formed. The observed nonlocal transport features of photoexcited carriers may be related to the topological states contribution.

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Nonlinear Optical Effects in Isolated Oligomers of Mie-Resonant Nanoparticles Excited by Gaussian and Vector Beams

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Nanostructures based on high-index dielectric nanoparticles with optical response governed by multipolar Mie-type resonances have been proved to enhance the efficiency of nonlinear optical effects [1]. Combining dielectric particles in oligomers leads to the collective modes formation governed by near-field coupling between the constituent nanoobjects [2], which results in largely increased nonlinear optical response [3]. This effect is sensible both for the nanocluster geometry and laser excitation conditions [4] such as pump beam polarization.

In this work, we studied experimentally and numerically the third-harmonic generation (THG) from isolated subwavelength oligomers made of three and four Si nanodisks in spectral vicinity of their magnetic dipolar Mie type resonance (MDR) under different fundamental beam polarizations (azimuthal (AP), radial (RP) and linear (LP)). We made THG intensity spectroscopy of isolated nanoclusters using nonlinear microscopy setup based on near-infrared femtosecond laser for AP, RP and LP and sample azimuthal angle rotation. We demonstrated that the THG power from samples pumped with AP vector beams is two orders larger comparing to the LP pump beams on the wavelength of the collective out-of-plane magnetic modes excitation by AP light and two times larger comparing to the same AP illumination but on the wavelength of MDR. We also observed the rotational dependence of the THG signal from the clusters pumped by LP beams in accordance with

their point-group symmetry governed by near-field interaction of nanodisks. Experimental data are in a good agreement with analytical and numerical predictions.

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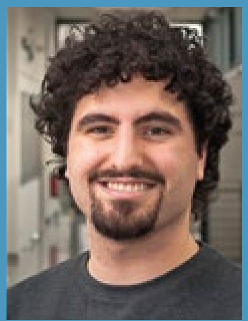
Quantum Computation Based on Photonic Chips and Trapped Neutral Atoms

In this work, we will consider state of art and original results in the field of Quantum computations. In particular, we will discuss two physical platforms based on photonic chips and trapped neutral atoms, advantages and troubles with experimental implementations. Basically, the talk covers the following issues:

- Integrated optics for photonic quantum computation;
- Linear-optical quantum computing;
- Fabrication of integrated photonic devices;
- Reconfigurable devices;
- Single atoms in optical microtraps for quantum computing;
- Optical traps for single atoms;
- Scaling up the system: holographic traps coherence and logical gates.



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Orchestrating PDC Temporal Modes

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Temporal modes are field-orthogonal spectral-temporal amplitudes of light pulses, for instance Hermite-Gauss functions. They form a high-dimensional basis which can be used for networked quantum information applications [1]. There are several aspects that render temporal modes appealing basis states. They can be densely packed in time-frequency space, they are naturally compatible with single-mode fibres, and, due to their pulsed nature, they lend themselves to precise timing measurements. To fully unlock their potential, however, we need the ability to generate photonic quantum states that exhibit a tailored temporal-mode structure.

We can address this challenge by deploying dispersion-engineered parametric down-conversion (PDC). Using our group-velocity matched PDC source as basic tool [2], we generate photon-pair states with well-defined dimensionality and user-controlled temporal-mode distribution [3]. To do so, one only needs to shape the complex spectrum of the pump pulses, which means that a change of operation mode, say from single-mode to few-mode, doesn't require any additional experimental overhead. The underlying temporal-mode structure of multi-dimensional states can be described via the Schmidt decomposition. The second-order correlation function of the states depends directly on the number of modes and provides a good figure of merit for experimental demonstration [4].

Here, we experimentally demonstrate full control over PDC states with up to ten temporal-modes. By measuring both the joint spectrum of the generated photon pairs as well as broadband Glauber correlation functions of individual PDC outputs, we conclusively show that not only can we control the number of modes, but also their relative weights. These results pave the way towards applications based on user-defined multi-dimensional quantum states of light.

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High Order Fano-Resonances and Extreme Effects in Field Localization

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Fano resonances resulting from the interference of broad and narrow excitation modes have emerged with many promising applications in physical, chemical, and biological sciences [1]. The sharpness and the amplitude of the Fano resonance increase for higher order mode, e.g. interference of the broad dipole (Rayleigh) mode and narrow octupole mode provide a sharper resonance than a similar interference of the dipole and quadrupole mode in plasmonic particle (see e.g. Fig. 3 in Ref. 1). Excitation of the higher order Fano resonances [2] permit to enhance the sensitivity of resonant nanostructures. High order Fano resonances (quadrupolar, octupolar, hexadecapolar, and triakontadipolar) were generated in the optimized disk ring silver plasmonic nanostructure [2]. However, further progress towards higher order resonances is quite complicated due to the dissipation within the plasmonic structures in the visible range. On the contrary, in dielectric materials dissipation effect can be very small, which permits to realize high order Fano resonances. The weakly dissipating dielectric spheres (glass, quartz, etc.) permit to realize high order Fano resonances for internal Mie modes. These resonances for specific values of the size parameter yield field-intensity enhancement factors on the order of 10^4–10^7, which can be directly obtained from analytical calculations. These "super-resonances" provide magnetic nanojets with giant magnetic fields, which is attractive for many applications [3].

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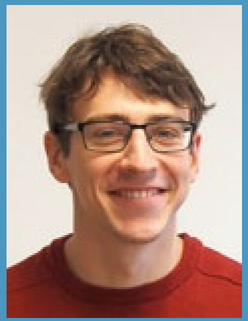

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Realisation of Photonic Anomalous Floquet Topological Insulator

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We undertake the first observation of a photonic anomalous Floquet insulator in the waveguide regime. In contrast to the common understanding, the system exhibits topological edge modes despite vanishing Chern number of all bands.

The solid-state concept of topological insulators is associated with extraordinarily robust edge transport. The idea of transferring topological protection to electromagnetic waves [1] was first realized in the microwave regime [2] and recently brought to the optical domain [3,4], and may enable novel and more robust photonic devices. It is commonly accepted that for two-dimensional spin-decoupled topological systems a complete topological characterization is provided by Chern numbers [5] – the number of chiral edge modes residing in a band gap is given by the sum of the Chern numbers of all bands below this gap. Hence, the Chern number is equal to the difference between the chiral edge modes entering the band from below and exiting it above. However, this is strictly true only for systems that are static, that is, where the Hamiltonian is constant in the evolution coordinate. To characterize periodically driven (Floquet) systems, it was shown recently that the appropriate topological invariants are winding numbers [6]. They use the information in the Hamiltonian for all times within a single driving period.

In our work, we experimentally demonstrate so-called anomalous Floquet topological insulators (A-FTI) with chiral edge states being present although the Chern numbers of all bands are zero. To this end, we employ arrays of evanescently coupled waveguides. This is the first explicitly driven system to show this phenomenon which, up to now, has only been implemented in static network systems which can be mapped onto a Floquet Hamiltonian [7]. In the structures applied within our work, the light evolution is governed by a Schrödinger equation (see Ref. [8] for details) in two transverse directions x and y with an evolution along the z coordinate, constituting the system an excellent quantum simulator. We consider a bipartite square lattice with two site species A and B (with same on-site potential), as it was suggested in [6]. Along the propagation direction, the structure consists of four sections with each having length $T/4$, and the entire period is T. In the first section, a particular A-site couples to neighboring B-site on its right, in the second section to its neighboring B-site above, and in the third and fourth section to its left and below, respectively (as sketched in Fig. 2a). The inter-site coupling in the individual sections is achieved by appropriately engineering directional couplers as sketched for one unit cell and one period in Fig.1(a). This system is described by the Bloch-Hamiltonian:

$$H_{\mathrm{B}}(\vec{k},z) = -\sum_{j=1}^{4}\begin{pmatrix} 0 & c_j(z)e^{-i\vec{b}_j k} \\ c_j(z)e^{-i\vec{b}_j k} & 0 \end{pmatrix},$$

where the vectors $\{\vec{b}_j\}$ are given by $\vec{b}_1 = -\vec{b}_3 = (a,0)$ and $\vec{b}_1 = -\vec{b}_3 = (a,0)$, with a being the distance between adjacent lattice sites. Additionally, for each partial step n, the coupling coefficients $\{c_j(z)\}$ are defined as $c_j = \delta_{jn} c$. The coupling coefficient is chosen as $c = 2\pi/T$, such that during each step complete coupling into the respective neighboring waveguide occurs. As a result, this configuration exhibits no transport in the bulk as an excitation is trapped by moving only in loops, whereas at the edge transport occurs (see Fig. 2b). Obviously, the Hamiltonian is z-dependent, which for waveguide lattices is analogue to time-dependence in quantum mechanics [8] and, hence, no eigenstates exist. However, due to the periodicity in z, Floquet theory can be applied to derive a band structure of so-called quasi-energies [6] in full correspondence to Bloch's theory for spatial periodicity. Consequently, the Floquet spectrum is periodic in its quasi-energies as the transverse momentum caused by Bloch's theorem. Our lattice structure exhibits two flat degenerate bands (that appear as a single band), as the bipartite character of the lattice arises only from the sequential coupling steps with four equal coupling coefficients c_j. Since the sum of the Chern numbers of all bands has to be zero, we find that the Chern number of the flat band in our system is zero. Though, when considering a finite system, we observe the formation of chiral edge states (see Fig. 2d). In this vein, the Chern number is not the appropriate topological invariant that characterizes the existence and the amount of chiral edge states in our system. This is the very nature of an A-FTI.

For the experiments, light is launched into single sites of the laser direct-written lattice and the light dynamics is observed as summarized in Fig. 1(d)-(g). As readily identifiable, the excited edge state travels dispersionless and without any scattering along edges, around corners and various defects (Fig. 1(d)-(f)). This highly robust, unidirectional state is a clear signature of topological protection. However, as opposed to the common Floquet topological insulator, in our system we find a flat band of bulk modes. This is shown by exciting the sites in the bulk of the lattice and observing that light is trapped in a loop, indicating the excitation of only localized modes (see Fig. 1(g) for one example). As we observe the same dynamics for any bulk site, we can conclude that there is indeed only one band, which consists of localized degenerate states: A single flat band, which has to have a Chern number of zero. This is the unequivocal proof of having implemented an A-FTI, as clearly the Chern number does not predict the existence of the chiral edge states.

Summarizing our work, the results presented here clearly demonstrate the significance of the winding number as the appropriate topological invariant characterising periodically driven systems. Our experimental observation of an A-FTI in a photonic chip opens a new chapter in the field of topological physics. Based on this results on-chip photonic circuitry and slow light is feasible.

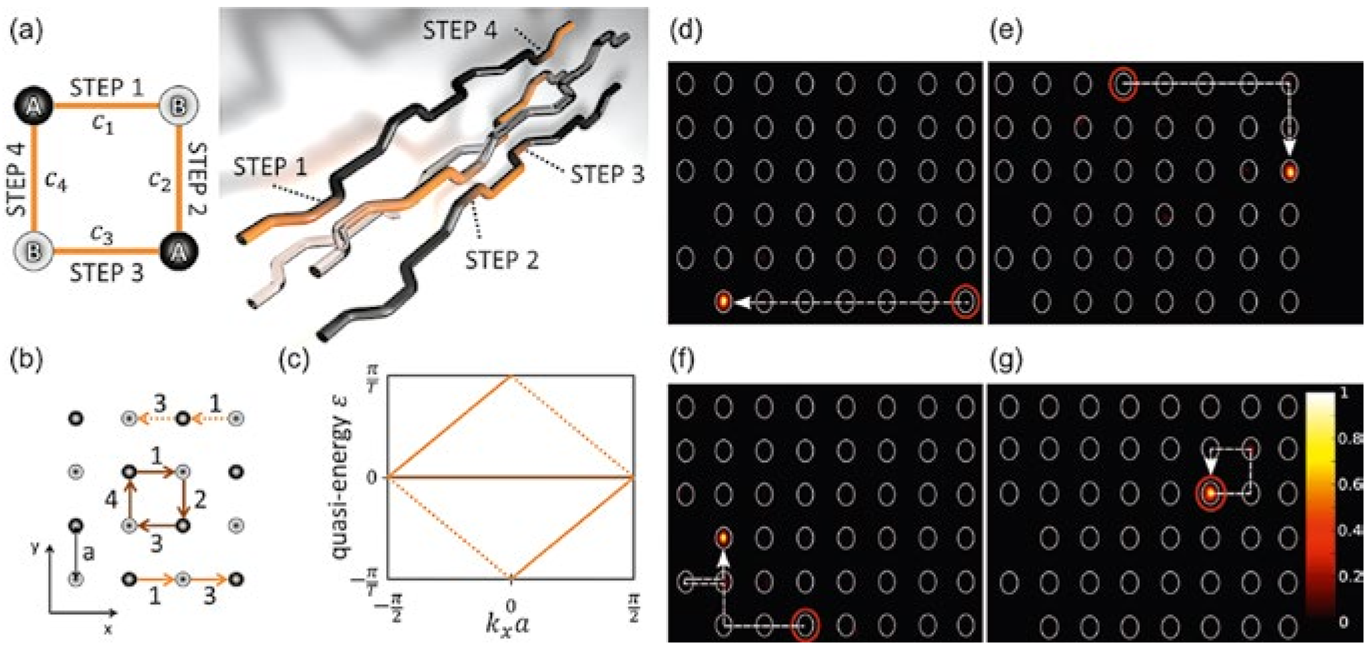

Figure 1(a). One lattice unit cell with four different coupling steps and schematic of its waveguide implementation bringing each waveguide pair together during each respective coupling step. (b) Sketch of light propagation during four different steps exhibiting transport along the edges and localization in the bulk after a full period with complete coupling per step. (c) Associated quasi energy edge band structure with flat bulk band and dispersionless topological edge modes. (d)-(g) Experimental light output images after three full periods while exciting a single waveguide (marked by red ellipse). Evolution of the chiral edge state (d) along the edge, (e) around a corner, and (f) along artificial defects in the lattice structure. (g) In the bulk, light follows a loop trajectory, as only localized flat-band modes are excited.

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Optically Pumped Magnetometers – Quantum Sensors for a Variety of Applications

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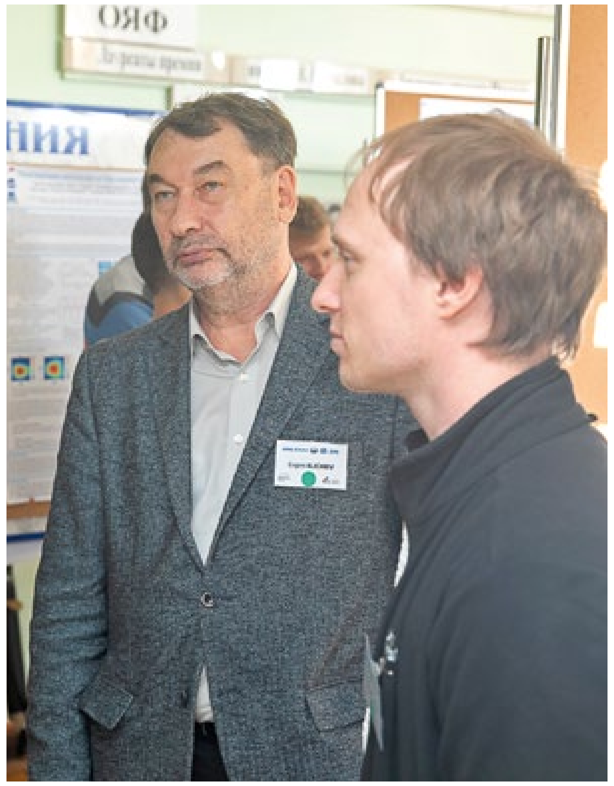
Optically pumped magnetometers (OPMs) are quantum sensors based on the interaction of atomic vapors with the external magnetic field. Usually alkali atoms are used due to their favorable electronic structure. Especially when exposed to a magnetic field, these materials feature a large Zeeman Effect. Additionally, their large electrical dipole moment allows convenient manipulation and readout by the aid of laser radiation at readily accessible wavelengths.

Recent advances in the miniaturisation [1] and scalability of the required alkali vapor cells open the path to applications in the field of sensor arrays for biomagnetic fields and miniaturized atomic clocks. Employing recently developed operational modes, such as the Spin-exchange relaxation-free [2] and light-shift dispersed Mz [3] modes, sensitivities in the single-digit fT range have been realised; and using the latter method even magnetically unshielded, highly-sensitive measurements within the Earth's magnetic field become possible. In mobile, unshielded applications, moveable OPM instruments should be able to operate at field amplitudes of the order of 50 µT at which they are usually influenced by heading errors. This term summarizes systematic measurement errors and sensitivity changes depending on the sensor orientation. We will report on experimental and theoretical studies about such effects [4,5].

Another interesting application for OPMs lies in the field of fundamental physics. Theory predicts interactions of spin systems with special kinds of dark matter, namely axions or axion-like particles. We will shortly introduce our work connected to this interesting topic.



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Tracing Light-Matter Coupling on the Nanometer Length- and the Femtosecond Timescale

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Interesting low-energy elementary excitations, such as phonons, plasmons and magnons, strongly interact with light in the terahertz and mid-infrared spectral domain. Ultrafast optical spectroscopy has provided key insights into the dynamics of these collective excitations. Unfortunately, the spatial resolution of such (far-field) studies is intrinsically limited to the scale of the probing wavelength by diffraction. Thus, the optical response cannot resolve individual nano-objects, confined polariton waves, or local surface effects.

In this talk, I will show how we use ultrafast scanning near-field optical microscopy to bypass this limitation and to gain access to the transient, nanoscale dielectric functions [1] of materials after photo-excitation by femtosecond near-infrared pulses. We have applied this technique – simultaneously achieving a 10 nm spatial and 10 fs temporal resolution – to study carrier dynamics in single semiconductor nanowires on their intrinsic length and time scales [2,3]. Furthermore, we directly observe photo-activated surface polaritons in real space and trace their decay dynamics [4]. Most recently, also the ultrafast vertical charge transfer based on transition metal dichalcogenides (TMDCs) has attracted significant interest [5], especially the ultrafast formation of interlayer excitons [6]. With our approach, we can resolve the spectral change between single TMDC flakes and heterostructures with nanometer spatial resolution and reveal spatial contrast in the conductivity of a single heterostructure, which are not linked to topographic features. We also monitor the change of the local scattering response upon photoexcitation and even resolve the local terahertz emission due to the ultrafast interlayer charge transfer.

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Optical Switching in One-Dimensional Photonic Crystal Enhanced by Bloch Surface Waves

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Bloch surface waves (BSWs) are propagating electromagnetic modes which can be excited at the surface of one-dimensional (1D) photonic crystals (PC) [1]. These states are excited within the photonic band gap spectral region for different polarizations of incident radiation; they demonstrate long propagation length (up to several millimeters range [2]) along with prolonged lifetime and manifest themselves as narrow spectral-angular resonances in reflectance spectra. The BSWs optical properties lead to considerable interest to photonic devices and optical sensors based on BSWs. The possibility of using BSWs to create waveguides [3], sensors [4] and elements of integrated circuits [5] had been recently studied, while the possibility of using BSWs as optical modulators hasn't been studied so far.

In this work, we study the ultrafast dynamics of BSWs in 1D PC. The pump-probe technique in Kretschmann prism configuration was used. In the experiment, the value of relative change of reflectance coefficient (dR/R) was measured. We obtained the optical switching with characteristic switching time around 1 ps at excitation of PC by Ti:Sapphire laser (750–850 nm) with duration 50 fs. Using the spectral dependence of the value of dR/R, a significant increase of dR/R at the wavelength corresponding to the BSW resonance was observed. The dependence of the switching modulation on the nonlinearity of the PC upper layer was demonstrated by placing a monolayer of graphene to the PC surface.

The presented data demonstrate the possibility of creating optical modulators based on BSWs.

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Efficient Single-Photon Source at 200 K Based on a CdSe Quantum Dot in a Photonic Nanowire

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In the last decades, a lot of attention has been paid to development of the sources of quantum light such as single-photon emitters possessing non-classical photon statistics and sources of entangled pairs of single photons. These devices are key elements for the systems of quantum cryptography, information teleportation, and quantum computing. Self-organised single quantum dots (QDs) based on wide-gap II–VI compounds, grown by epitaxial techniques (usually by molecular beam epitaxy (MBE)), are considered as promising candidates for creation of the room-temperature single photon sources due to exceptionally large binding energy of excitons and biexcitons. So far, single-photon emission at elevated temperatures has been demonstrated for the structures with CdSe/Zn(S,Mg)Se [1] and CdTe/ZnTe [2] epitaxial QDs and room temperature operation has been achieved under both optical [3] and electrical [4] pumping. The fabrication of intense II–VI single-photon sources is, nevertheless, hampered by a difficulty with growth of monolithic cavity structures suitable for increasing extraction efficiency of the single-QD emission.

In this work, we demonstrate a relatively simple approach to improving the photons collection efficiency, based on hybrid semiconductor-dielectric and semiconductor photonic nanowires. To this purpose, the 1.5 μm-thick ZnMgSSe layer for semiconductor nanowire was grown by MBE on the surface of the structure with CdSe QDs and ZnSSe/ZnMgSSe barriers. For semiconductor-dielectric nanowire, the heterostrucure with CdSe QDs was covered with a thick layer of a transparent e-beam resist. After performing the focused ion beam etching, the photonic nanowire with carefully tailored ends can be obtained. Using thus fabricated photonic structures we demonstrated the single-photon flux with an average intensity exceeding 1 MHz at the temperature of 80 K for semiconductor-dielectric nanowire [5] and at the temperature of 200 K for semiconductor nanowire.

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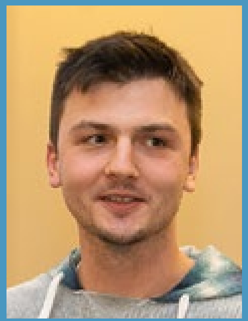

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Evaluation of the Possibility of Dynamic Phase Holograms Usage for Single Atom Arrays Reconfiguration

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Cold single atoms are the ones of the most promising candidates to be considered as physical qubits [1]. Unfortunately, "collisional blockade" regime, that allows one to load single atoms into dipole trap, reduces probability to catch an atom down to 0.5 that prevents production of fully loaded single atom arrays. The common way to overcome this issue is to create reconfigurable atomic arrays [2, 3]. This could be done via computer generated dynamic phase holograms displayed by spatial light modulator (SLM), that give rise to the possibility to move several atoms at once. The goal of current work was to estimate the scope of this method. It was demonstrated that intensity flicker which arises while the image displayed by SLM updates causes almost no heating. Moreover, it was shown that probability of successful atom movement is limited mostly by atom lifetime in dipole trap, therefore, the maximum distance that an atom could be transferred is determined by SLM refresh rate. It was demonstrated that the possible size of single step of atom movement is significantly bigger than $1/e^2$ radius of the focal spot size of the dipole trap due to finite time of image update. Acquired data was fitted by results of Monte-Carlo simulation for atom movement. Also, we introduce our modification of Gerchberg-Saxton algorithm that could be used for intensity flicker minimization. Nevertheless, development of an effective algorithm for phase holograms generation is an object for further discussions.

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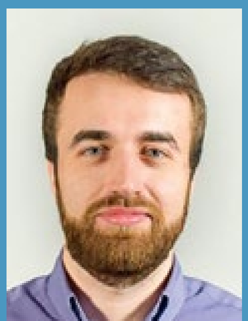

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Single Photon and Entangled Photon Pair Generation Using Tapered Optical Fibers

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Single-photon and entangled two-photon states are the core of optical quantum computing and quantum communications [1]. Non-classical states of light can be generated via nonlinear optical effects, such as spontaneous parametric down-conversion and spontaneous four-wave mixing (SFWM) [2]. Particularly, the latter is observed in the standard silica optical fibers that are widely used in the telecommunication net. One of the most promising medium for SFWM observation is tapered optical fiber [3–7]. Tapered optical fibers allow one to observe nonlinear optical phenomena at very low pump power (less that 10 nW) [8], manipulate single atoms [9], achieve high-efficiency coupling between light and matter [10], etc.

In this work, we discuss SFWM in tapered optical fibers in terms of their use for generation of non-classical states of light: single-photon and correlated two-photon states. We fabricated a bunch of identical tapered optical fibers and observed SFWM in them. For the source characterization, we measured several functions, including spectral intensity of the created field and heralded auto-correlation histogram. All the performed measurements prove quantum nature of the generated light.

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Femtosecond Laser Writing Technology for Integrated Quantum Photonics

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Direct femtosecond laser writing technology is a powerful tool for integrated photonics. It is based on a local and permanent change in the refractive index (up to 10^{-2}) of various transparent dielectric materials under the action of tightly focused ultrashort laser pulses (300 fs), and allows in one stage to prototype various kinds of three-dimensional integral elements and devices based on waveguides in optical glasses and crystals [1].

This technology has also recommended itself in solving problems of quantum optics on miniaturization and increasing work stability by integrating quantum computing circuits and control elements into a monolithic optical chip. We have created and tested a programmable 4-channel optical circuit on a chip, consisting of 6 interferometers and implementing universal unitary transformations [2]. Heating elements (electrodes) that control the parameters of integrated interferometers due to the thermo-optical effect have also been formed using this technology. In addition, waveguides with depressed cladding inside $7LiYF_4$ crystals with rare-earth erbium ions were created and studied [3]. These waveguides can serve as a base for integrated optical quantum memory on photon echo.

Currently, work is underway to create an integral device for controlling the polarization of a photon, based on polarization beam splitters [4]. And it is also planned to create quantum optical computing elements based on quantum random walks of photons on a lattice of coupled waveguides.

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Optical Studies of SiV Colour Centres in Phosphorous-Doped Diamond

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A robust narrow-band solid-state single photon source is desirable for applications in quantum cryptography and quantum computation. Silicon vacancy (SiV) colour centres are promising candidates as most of the fluorescence emission (>90%) [1] is concentrated in a narrow zero phonon line. In addition, the centre exhibits a short excited state lifetime of ~1 ns [1] and a small inhomogeneous linewidth broadening.

For efficient operation and integration into devices, SiV single-photon sources operating upon electrical injection are necessary. This possibility has been recently shown by few research groups based on p-i-n diode structures [3,4]. Although the colour centres operate well at room temperature, the emission rate is small as compared to semiconductor quantum dots excited in a similar fashion. However, theoretical studies show that by efficient electrical pumping an emission rate of 100 MHz could be reached [2].

Currently, we aim at developing efficient electrical pumping schemes of SiV colour centres to obtain emission rates in the order of 100 MHz in phosphorous doped diamond. Optical characteristics show that background due to doping of phosphorous and ion beam induced unwanted defects during silicon implantation can be significantly suppressed. This enables the observation of single SiV colour centres in phosphorous-doped diamond samples by optical excitation.

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Light-Emitting Dielectric Metasurfaces

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All-dielectric nanoparticles with a high refractive index can support electric and magnetic multipolar Mie-type resonances [1], which can be tuned by the nanoparticle geometry and environment [2]. Thereby, they offer unique opportunities for engineering their near-field and far-field responses, while exhibiting very low absorption losses [3]. In particular, semiconductor nanoresonators were extensively used as building blocks of wavefront-shaping metasurfaces. However, Mie-resonant semiconductor nanoparticles can also be employed as building blocks of optical nanoantennas, exhibiting high directivity, Purcell enhancement, and near-unity radiation efficiencies [4].

This talk will provide an overview of our recent advances in enhancing and tailoring light emission in the visible and near-infrared spectral range by metasurfaces composed of designed Mie-resonant semiconductor nanoparticles hybridized with various types of emitters, including semiconductor quantum dots [5], monolayers of transition metal dichalcogenides [6], and trivalent lanthanide ions [7]. We also consider metasurfaces composed of nonlinear materials, which, when pumped at the fundamental frequency, emit light at new frequencies via various nonlinear frequency generation processes [8–10].

In order to characterize the emission properties of the light-emitting metasurfaces, we perform micro-photoluminescence imaging, spectroscopy, and Fourier imaging for a variety of different metasurface architectures. Our results show that Mie-resonant metasurfaces provide a powerful platform for manipulating the spectral and directional properties of both spontaneously emitted and nonlinear generated light.

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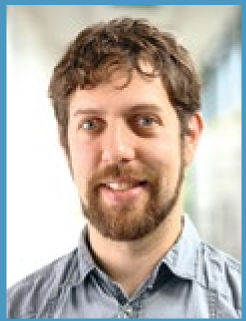

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Optical Squeezing From Lithium Niobate Waveguide Resonators

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Optical squeezing was first demonstrated in the 1980's [1] but it has taken a number of decades for the technology to improve and mature to a level where it is beginning to find everyday usage. For example, squeezed states of light are now routinely used to enhance the sensitivity of laser interferometric gravitational-wave detectors [2] and can be used for quantum key distribution protocols [3].

Much like the development of integrated devices was crucial in establishing a global fibre network, it is also expected that similar integrated devices will be required to generate, manipulate and detect squeezed states. This is due to the fact that these integrated devices offer reproducibility, stability and miniaturization on a scale that is generally not possible with standard bulk optics setups.

Whilst shifting these devices towards integrated solutions presents many advantages, generation and manipulation of these states has been somewhat limited, due primarily to the increased losses typically observed in these systems, imperfection in the waveguides and the oft observed photorefractive damage.

Here we present our recent squeezing results from an integrated waveguide resonator [4]. Using an 8mm long titanium-indiffused lithium niobate waveguide and by coating both ends of the sample with dielectric coatings, a waveguide resonator is constructed. This resonator is pumped with 25 mW of 775 nm light (also generated in a waveguide resonator [5]) and single-mode vacuum squeezing is produced at 1550 nm. Using balanced homodyne detection 2.9 dB of squeezing is directly observed, corresponding to 4.9 dB of squeezing exiting the waveguide.

The presented results show that the titanium indiffused waveguide system is capable of producing large levels of squeezing and is a promising platform for further investigation.

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Single-Photon Sources of Red Light Based on Tapered Nanowires with an InAs/AlGaAs Quantum Dot

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The development of quantum cryptography for protected optical communication lines as well as of linear optic quantum computations rely on nonclassical light sources capable of emitting single photons on demand at a defined frequency with high quantum efficiency [1]. Self-organised single quantum dots (QDs) grown by epitaxial techniques are most promising candidates for the creation of such devices. In this work, we investigate the possibility of creating an efficient single-photon source for the red part of the spectrum with wavelengths around 700 nm and shorter. This spectral range is especially attractive since it is the region of the highest sensitivity of modern single-photon avalanche diodes based on Si. Furthermore, it is suitable for the development of protected lines of atmospheric and airspace optical communication.

The developed source is based on InAs/AlGaAs QDs grown by molecular beam epitaxy [2]. We investigated the statistics of correlations of photons emitted by a photonic nanostructure, in which an InAs/AlGaAs QD was placed in a columnar (nearly cylindrical) AlGaAs waveguide with a variable cross section. Such a waveguide, fabricated by dry reactive ion etching through a sapphire nanoparticle, operates essentially as a photonic nanoantenna coupling the QD emission to far optical field. By properly choosing the parameters of the waveguide (base diameter, refractive index, and height), it is possible to increase the efficiency of the radiation extraction many times [3]. The use of such nanoantennas allowed us to implement a bright source of single photons with an average intensity exceeding 16 MHz at the temperature of 10 K with the autocorrelation function $g^{(2)}(0) = 0.03$.

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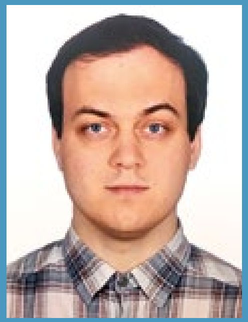

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Manipulation of Quantum Dots Photoluminescence with Resonant Dielectric Nanostructures

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Semiconductor quantum dots (QDs) [1] are nanoscale light sources, whose optical properties can be engineered. Indeed, control over the size and/or composition of the QDs structures allows for a tuning of the absorption and emission peak wavelengths. Moreover, QDs have potential applications in quantum computing and quantum cryptography, as they can act as single or entangled photon sources. However, since QDs are much smaller than the wavelength, these applications suffer from the QDs' weak interaction with electromagnetic field.

Metasurfaces such as two-dimensional arrays of Mie-resonant dielectric nanoparticles provide a promising route for improving and controlling the excitation and emission of QDs coupled to them [2]. First, the metasurfaces can strongly confine and enhance the excitation field at the positions of the QDs, thus increasing the excitation rate. Next, the resonances of the metasurfaces at the emission wavelength enhance the local density of states, which modulates the radiative decay rate of the QDs via the Purcell effect and can improve their quantum efficiency. Finally, the metasurfaces can tailor the QD emission pattern into a single narrow lobe to achieve a better collection efficiency in the experiment. In our work we study the spectral reshaping and the directional properties of photoluminescence (PL) from InAs QDs integrated into Mie-resonant GaAs metasurface. We perform PL spectroscopy, back-focal-plane imaging and momentum-resolved spectroscopy of the emission from the metasurface. We demonstrate spectral and spatial control of PL, which is achieved by coupling of the emission into the Mie- and lattice modes excited in the metasurface.

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Non-Hermitian Quantum Walks in Coupled Optical Fiber Loops

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Coupled optical fiber loops are a very promising experimental platform for demonstrating complex phenomena that were inspired from various fields of physics.

It was recognised that light propagation in coupled optical fiber loops can be mapped onto a system that performs a one-dimensional discrete-time quantum walk (DTQW) [1]. This implementation is based on the fact that DTQWs are interference phenomena, that can be obtained by purely classical means [2]. The basic properties of DTQWs in fiber loops are currently well understood and studied both theoretically and experimentally [3]. One particular interest is the influence of disorder on quantum walks. A celebrated example is the so-called Anderson localization (AL) phenomenon associated with a localization of quantum states and halt of transport in a random medium due to interference effects originating from multiple-scattering events [4]. While in previous experiments on AL the wave localization originates from randomness pertaining to the spatial profile of the real part of the potential, just recently, the emergence of localization phenomena in a different setting, namely a class of systems, whose spatial potential profile has random dissipative part, has been predicted [5].

The fiber loop system allows for the implementation of well-controlled dissipative quantum walks. Thus, we report the first experimental realization of the predicted localization in randomly dissipative quantum walks. Additionally, an intriguing spatial hopping of the localized wave packet is observed, although all Floquet-Bloch modes are localized. This observation, which seems to be a unique feature of non-Hermitian systems, imposes new exciting perspectives on the localization of quantum states in dissipative (open) quantum systems.

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HgTe Nanowires as Platform to Search for Majorana States

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The discovery of 2D and 3D topological insulators (TI) has opened an exciting new area of condensed matter physics. It has been theoretically predicted [1] and recently shown experimentally that strained HgTe films constitute a 3D TI [2-4]. This means that two-dimensional surface states with Dirac type electron dispersion and high electron mobility enclose the insulating bulk of HgTe. The advantage of exploring 3D HgTe is its very high electron mobility, which allows probing of mesoscopic effects. After introducing some basic measurements to characterise the topological electron system (transport, (magneto-)capacitance, cyclotron resonance) I am focusing on measurements on HgTe nanowires [5] aiming at realizing topological superconductivity [6]. To explore topological superconductivity we realize Josephson junctions by placing superconducting stripes across the wire and search for the fractional (4p–) Josephson effect [7] exploring Shapiro steps under microwave irradiation [8].

Work done in close collaboration with J. Ziegler, R. Fischer, H. Maier, D. A. Kozlov, Z. D. Kvon, N. N. Mikhailov, S. A. Dvoretsky, R. Kozlovsky, C. Gorini, M. H. Liu and K. Richter.

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Exciton Propagation in Monolayer Semiconductors

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Coulomb-bound electron-hole pairs, or excitons, have been in the focus of the solid-state research for many decades [1,2]. They are of paramount importance for the fundamental understanding of interacting charge carriers in semiconductors [3]. More recently, they were found to dominate the electro-optical properties in two-dimensional single layers of semiconducting transition-metal dichalcogenides (TMDCs) and their heterostructures [4–6].

In contrast to a number of nanoscale systems, an intrinsic property of excitons in these materials, is their ability to freely move in the two dimensions across comparatively large distances [7], in close analogy to quantum well systems [8,9]. More importantly, however, the high exciton binding energies in these systems allow for the investigation of exciton dynamics, such as propagation and density driven non-linear phenomena even at room temperature and ambient conditions.

In our study [10], we address these topics by directly monitoring the spatial behaviour of optically excited excitons in WS_2 monolayers under a wide range of excitation density. We find highly non-linear behaviour with qualitative changes in the spatial emission profiles and an increase in the effective diffusion coefficient, depending on the injected exciton density.

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SCIENCE ORGANISATIONS

FACULTY OF PHYSICS MOSCOW LOMONOSOV STATE UNIVERSITY

Professor Dr Nikolay N. Sysoev
Dean of the Faculty of Physics, Moscow Lomonosov State University

Faculty of Physics is a major training and research centre and a leading institution in the field of physics education in Russia.

Physics has been taught at Moscow University since 1755 when the Department of Experimental and Theoretical Physics was opened at the first Russian university. The Faculty of Physics and Mathematics was founded in 1850, while the Faculty of Physics was established in 1933. Since that time, the Faculty has constantly been expanding and widening the scope of its research and academic activities.

At the Faculty, research is carried out in practically all fields of fundamental and applied modern physics.

The Faculty consists of eight Departments and includes 39 Divisions (Chairs). It closely cooperates with plenty of Russian and foreign research centres and universities that regularly carry out schools, seminars, conferences.

Since 1933, the Faculty have trained over 28,000 physicists and have awarded over 4,000 Candidate and 500 Doctor degrees. A third of the members of the Russian Academy of Sciences, experts in Physics, Geophysics, and Astronomy, are our graduates.

Today, the Faculty is training 2500 undergraduates, 400 post-graduates; we employ 20 academics and corresponding members of the Russian Academy of Sciences, 120 professors, 300 instructors, 330 research fellows, 200 candidates and 500 doctors of science.

35 Faculty's professors have become Honored Scientists of Russia; 8 Nobel Prize winners have worked at the Faculty, as well as 38 Lenin Prize winners, 172 State Prize winners, and 78 Lomonosov Prize winners.

Six divisions of the Faculty (Experimental and Theoretical Physics, Solid State Physics, Radio Physics and Electronics, Nuclear Physics, Geophysics, Astronomy) with their 39 departments offer fundamental education covering nearly all the branches of modern physics: Experimental and Theoretical Physics, Geophysics and Astronomy, Nuclear and Particle Physics, Accelerator Physics, Solid State Physics, Radio Physics and Quantum Electronics, Nonlinear Optics and Laser Physics, Classical and Quantum Field Theory, Theory of Gravitation, Earth Physics, Atmospheric, Oceanic and Planetary Physics, Cosmic-Ray Physics and Cosmophysics, Black Holes and Pulsar Astrophysics, Biophysics, Medical Physics, etc.

The Faculty of Physics has its own well-equipped laboratories and affiliations with research centres, such as the Shternberg Astronomical Institute and the Scobeltsyn Nuclear Physics Institute. Some of our departments are located outside Moscow, at the High Energy Physics Institute (Protvino, Moscow region), at the Joint Institute for Nuclear Research (Dubna, Moscow region), and at the RAS scientific centres in Chernogolovka and Pushchino.

With our international links with universities in Europe, America and Japan, our senior students may participate in internship programs and write their graduation papers at universities, research centres, and institutes abroad.

As the Faculty of Physics trains researchers in physics, our students participate in research work from their second year – or earlier, if they wish. In their second year all our students write their first year paper.

Today the Faculty of Physics successfully competes in the field of research with the leading institutes of the Russian Academy of Sciences and holds the

highest ranks in fundamental physics globally. The presence of young researchers, students and post-graduates in a team is a competitive advantage of the Faculty over research institutes.

The Faculty of Physics enjoys all the benefits of modern computer and information technology. The core curriculum includes a compulsory 2-year Computational Physics and Software Engineering course, a number of general and special lecture courses follow in the senior years. Their IT training allows our students to contribute to developing new generations of computers and processor devices on new principles, such as optical memory and optical computers, neural networks, quantum information, quantum computers, quantum counting, etc., thus our graduates have competitive advantage in the labor market over "pure" IT professionals. Our senior students are offered optional program in Communications and Computer Network Security.

An old University tradition is very democratic relationships between professors and students which is true of the Faculty of Physics as well. Numerous issues concerning students' life are addressed by students themselves through self-governing organisations.

Our graduates have no problems finding a job in Russia or abroad. For them the doors are open to the most prestigious laboratories and research centres. The graduates also work successfully in other fields: economics, finance, business, management, etc.

DWIH Moskau
Land der Ideen

GERMAN CENTRE FOR RESEARCH AND INNOVATION (DWIH)

Dr Andreas Hoeschen
Director of the DWIH, Moscow

Mikhail Rusakov
Coordinator, DWIH Moscow

The German Centres for Research and Innovation (DWIH) are a network of German research organisations, universities and research-based companies. In five cities around the world, the DWIH provide a joint platform for German innovation leaders, showcase the capabilities of German research and connect German researchers with local cooperation partners.

The core mission of the German Centre for Research and Innovation (DWIH) in Moscow is to represent German science, research and innovation in Russia. It provides information about the German research and innovation landscape and helps connect German and Russian researchers and decision makers in science and innovation. Through its activities the DWIH Moscow aims to foster deeper science and technology collaboration between Germany and Russia.

The activities of the DWIH Moscow are supported by German organisations with a leading role in science and innovation which are represented in Russia, such as the German Academic Exchange Service, the German Research Foundation, the Helmholtz Association, the Contact Office of the Ministry of Culture and Science of North Rhine-Westphalia, the Freie Universität Berlin, the German Historical Institute, the University Alliance Ruhr, Thuringia International, the Representation of the State of Lower Saxony in Moscow, the Alexander von Humboldt Foundation and the German Russian Chamber of Commerce. 2019 RWTH Aachen joined the DWIH Moscow network as an associate supporter.

Since 1st January 2017, the German Academic Exchange Service (DAAD) is responsible for the management of the German Centres for Research and Innovation (DWIH). At the local level, the individual DWIH design their activities in cooperation with their supporters in a local Advisory Board.

DFG Deutsche Forschungsgemeinschaft

GERMAN RESEARCH FOUNDATION (DEUTSCHE FORSCHUNGSGEMEINSCHAFT, DFG)

Dr Jörn Achterberg
Director, DFG Office Russia/CIS

Dr Cosima Schuster
Engineering Science, DFG Bonn

Dr Astrid Evers
Research Careers, DFG Bonn

The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) is the biggest funding agency in Europe for the development of fundamental research with an annual budget of approximately 3 billion euro. Its membership consists of German research universities, non-university research institutions, scientific associations and the Academies of Science and the Humanities. The DFG has expanded its presence in other research regions around the world with its seven liaison offices. The office Russia/CIS was opened in Moscow in 2003. Framework agreements on the co-funding of research projects and researcher mobility exist with the Russian Foundation for Basic Research (RFBR), the Russian Science Foundation (RSF).

How does the DFG promote young researchers?
Creative and intelligent minds are the key to successful science and research. That is why the German Research Foundation places a special focus on promoting young researchers. We are committed to helping young talents pursue cutting-edge investigations in top-level settings and help them to become independent early on in their careers.

Flexible individual funding and customised excellence programmes give young researchers the opportunity to advance in their careers and undertake projects from all branches of science and the humanities. The DFG accepts funding proposals from researchers with a doctoral degree (PhD) who live and work in Germany or plan to do so in the future. PhD students are not supported individually, but can be, indirectly through the funding of programmes and projects.

Project-based doctoral and post-doctoral qualifications. For doctoral researchers, who like working in a team and value a well-designed framework, a **Research Training Group** (RTG) may be the right choice. It combines an ambitious research programme with target-oriented supervision and academic freedom to form an ideal environment for a successful doctorate. Post-docs help design the research and qualification programmes of an existing RTG and explore new research topics for your future career.

Following completion of the doctorate there is the possibility to assume responsibility as an **investigator in an existent DFG-funded project**. This will give young researchers the opportunity to advance their qualifications and improve their career prospects by gaining experience and by building new networks.

The **Temporary Position** is a funding mechanism that provides young researchers with funding for a temporary post-doctoral position in conjunction with a proposal for a research grant. Researchers may select the scientific setting in Germany that they think will provide the best conditions for their project.

Excellence programmes. The Emmy Noether Programme is aimed at outstanding scientists and academics with at least two and no more than four years of post-doctoral research experience (or up to six years for licensed medical doctors). It allows young researchers to head their own independent junior research group that will work on a project for five or, in exceptional cases, six years. It offers a fast-track opportunity to qualify for a leading position in research.

For young researchers, who have all the qualifications for a professorship, the **Heisenberg Programme** may be the right option. This programme provides them with funding for up to five years so they can distinguish themselves further academically. There are two variations of the programme: the portable Heisenberg fellowship, which also allows one to go abroad for some time; and the Heisenberg professorship, which offers the prospect of acquiring a tenured position at a German university, provided the candidate receives a positive review.

GERMAN ACADEMIC EXCHANGE SERVICE (DAAD)

Dr Andreas Hoeschen
Director of the DAAD Moscow

The German Academic Exchange Service (DAAD) is a self-regulating organisation of institutions of higher education in Germany. It is an intermediary in the implementation of Germany's foreign cultural policy and its policy in the field of education and science. DAAD supports international ties between institutions of higher education through the development of exchange among students, graduates and scientists within the framework of scholarship programs and projects.

DAAD:

- grants scholarships to Russian students as well as to young specialists and scientists for education and research-and-development training in German institutions of higher education, as well as in research-and-development institutions
- renders scholarship support to German students, trainees, graduates and young scientists for study at Russian institutions of higher education
- supports the development of international programs of education within the country and abroad
- promotes the spread of the German language worldwide
- sends lecturers and assistant professors to teach at foreign institutions of higher education
- is responsible for the development of partner relations between German and Russian institutions of higher education
- provides information on education and research in Germany and Russia.

THE HELMHOLTZ ASSOCIATION

Dr Elena Eremenko
Head of Helmholtz Moscow Office

The Helmholtz Association was created in 1995 to formalise existing relationships between several globally renowned independent research centres. The Helmholtz Association distributes core funding from the German Federal Ministry of Education and Research (BMBF) to its, now, 19 autonomous research centres and evaluates their effectiveness against the highest international standards. The Association's work follows in the tradition of its namesake, the natural scientist Hermann von Helmholtz (1821–1894).

The Helmholtz Association pursues the long-term research goals of the state and society, including basic research, in scientific autonomy. To do this, the Helmholtz Association conducts top-level research to identify and explore the major challenges facing society, science and the economy. Helmholtz Association scientists focus on researching the highly complex systems, which determine human life and the environment.

The Helmholtz Association brings together 18 scientific-technical and biological-medical research centres, a high-performance infrastructure and modern research management. With more than 40,000 employees and the annual budget of over € 4,8 billion, the Helmholtz Association is Germany's largest scientific organisation. Its work is divided into six research fields: Energy, Earth & Environment, Health, Aeronautics, Space and Transport, Matter, and Key Technologies.

Within the six research fields, Helmholtz scientists cooperate with each other and with external partners – working across disciplines, organisations and national borders. The Helmholtz Association uses this research to create an effective basis for shaping the future. An excellent research infrastructure – in some cases with unique major scientific facilities and instrumentation – clearly demonstrates the strength, which has made the Helmholtz Association a much sought-after research partner. Each year, several thousand visiting scientists from all around the world use the research opportunities that the Helmholtz Centres offer. The Association acts as a core focal point for worldwide research project – whether in the observation and study of the global climate or in the field of basic research in physics. The Helmholtz Association aims to be an active and driving force in establishing the research area worldwide. This is why Helmholtz opened branch offices in Brussels, Moscow and Beijing. In the autumn of 2018, the Helmholtz Association is scheduled to open an office in Tel Aviv/Israel.

The Helmholtz Association chose Russia to be one of its key strategic partners to jointly face the challenges of the future through scientific cooperation. Partners in Germany looking for specific information about Russia and Russian seeking contacts in Germany have an excellent starting point in identifying the right people for their special interests. The transfer of new technologies and the exchange of promising young research talent hold great potential for the future development of both Germany and Russia. The Moscow Office represents the interests of Helmholtz Association as a whole in Russia. It serves both Helmholtz scientists and Russian researchers interested in cooperation. Its main tasks are to provide help for scientific partners to establish contacts, to promote joint projects and to foster the exchange of scientists, with the goal of helping initiate and establish new strategic networks of scientific excellence between Russia and Germany.

THE FRAUNHOFER-GESELLSCHAFT

Guzel Shaykhullina
Senior Advisor
of the Fraunhofer Headquarters
in the Russian Federation

The Fraunhofer-Gesellschaft is the leading organisation for applied research in Europe. Its research activities are conducted by 74 institutes and research units at locations throughout Germany. The Fraunhofer-Gesellschaft employs 28 000 people, who work with an annual research budget of 2.8 billion euros. Of this sum, 2.2 billion euros is generated through contract research. Around 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

Mission. Applied research is the foundation of our organisation. We partner with companies to transform original ideas into innovations that benefit society and strengthen both the German and European economy.

Our employees shape the future – in ambitious positions at Fraunhofer or in other areas of science and business. Fraunhofer therefore places great importance on their professional and personal development.

Vision. Fraunhofer is the international leader of applied research.

As an innovation driver, we lead strategic initiatives to master future challenges and thus achieve technological breakthroughs.

Principles:
- Through our research we contribute to sustainable development of an ecologically sound environment, and an economically successful and socially balanced world. We are strongly committed to this responsibility.
- We promote a well-balanced combination of excellent research and application-oriented development. This unique characteristic motivates us and ensures added value for our partners.
- We understand our clients and know their challenges of tomorrow. Together we develop integrated solutions for their long-term success.
- We cooperate with the world's best in science and business. This strengthens our own innovative capacity and that of the German and European economy.
- We emphasize the great variety and interdisciplinary cooperation of our institutes. Faithful collaboration and team work promote synergies and enhance our performance.
- Our success relies on the knowledge and enthusiasm of our employees for applied research. Fraunhofer offers its staff excellent work conditions paired with a high degree of autonomy.

Customers and contractual partners are:
- Industry
- Service sector
- Public administration

Fraunhofer remains the leader among German research institutions in terms of the annual number of invention disclosures, patent applications and total industrial property rights. Its performance is outstanding even when compared with that of industrial enterprises. Over the last ten years, Fraunhofer has always ranked among the German Patent and Trade Mark Office's 10 to 20 most prolific patent applicants. Similar statistics compiled by the European Patent Office (EPO) have also placed Fraunhofer among the most active patent applicants.

Fraunhofer Gesellschaft, which provides contract research services to governments, multinational corporations and small to medium sized companies, is keen to tap into the Russian market for new business opportunities. Focused to move ideas quickly out of the lab and into the market, the group aims to help research organisations, start-ups and established businesses of all sizes to turn their innovative ideas into successful products and services.

The tasks of the Senior Advisor Fraunhofer Gesellschaft in Russia are:
- Forming a bridge to companies, excellent research organisations and governmental authorities
- Supporting Fraunhofer's Institutes in promoting and enhancing their business interests and increasing their contract research activity in Russia, mainly by acquiring projects.
- Assisting Fraunhofer's Institutes in establishing research co-operations in Russia and promoting the exchange of researchers.
- Initiating, organizing and coordinating relevant events, meetings and negotiations.
- Establishing and maintaining links to the responsible contact persons in the Fraunhofer Headquarters and to Fraunhofer Institutes where required.

FREIE UNIVERSITÄT BERLIN: BERLIN – AT THE EDGE OF BASIC AND APPLIED RESEARCH

Tobias Stüdemann
Liaison Office of Freie Universität Berlin in Moscow

The 9th Week of the Young Researcher stands in an already long line of conferences dedicated to bringing together young academics from Russia and Germany. Fostering careers in science by developing professional networks is one of the key elements of Freie Universität Berlin's career path model. Career development of young researchers was a cornerstone of the International Network University concept, successful in the German Excellence Initiative in 2007 and 2012 and will be continued as part of the objective Promoting Talent within the Berlin University Alliance, successful in the German Excellence Strategy in 2019. It is therefore no surprise that Freie Universität Berlin has been present at all prior weeks and has actively taken part with about half a dozen keynote speakers and more than a dozen doctoral students and young scientists. Interdisciplinary topics such as Men and Energy, Global History, Discrete Geometry, and Computational Biology and Biomedicine are core research fields of Freie Universität, and the conference weeks have therefore been actively supported by the Moscow liaison office from the very outset.

The three main formats of the Week – opening session, keynote lectures by experienced German and Russian scientists, and young researchers giving short presentation or participating in poster sessions – are open to all interested specialists and even students of the hosting institution. Early career researchers are actively involved in the conference and get a first impression on how conferences conducted entirely in English "feel". Especially in light of the rising demand to integrate oneself internationally into the scientific community, the weeks of the young researcher offer a great possibility to gain first experience. Many opportunities – not only during the lectures and scientific sessions, but also during excursions, evening receptions, and coffee breaks – are available for socialising and networking.

This year's conference location at Lomonosov State University of Moscow allowed young researchers and students to join for one or another session. Already for the fourth time, Moscow was an excellent place to organise the Week.

The role of Freie Universität Berlin's liaison offices, in seven countries around the globe, is not only to attract highly talented young researchers to the exciting scientific environment in Berlin. It also supports scientists in Berlin who are interested in foreign experience to learn more about the respective regions, to motivate them to pursue a research stay abroad, and to connect with (young) colleagues, e.g., in Russia. High-level conferences, like the 2019 Week on Quantum Science: Light-Matter Interaction are ideal for fostering networks between the next generations of scientists at the edge of basic and applied research. Although it is still a major challenge to plan scientific careers, Freie Universität Berlin offers excellent opportunities for career advancement, including structured doctorate programs with its professional development program and postdoc fellowships offered within the Dahlem Research School.

THE UNIVERSITY ALLIANCE RUHR LIAISON OFFICE MOSCOW

Elena Resch

Director of the Liaison Office Moscow, University Alliance Ruhr

The Ruhr Area is not only Germany's largest academic hub, but also an epicentre of innovation that fosters close interaction between academia and the private sector – and our alliance provides students and researchers from around the world with an open gateway to our region.

More than 120,000 students, of which 19,000 are international, as well as over 9,000 researchers study and work within the UA Ruhr universities (Ruhr University Bochum, TU Dortmund and University of Duisburg-Essen). Together, the three universities have 800 partnerships with universities in over 130 countries and a combined annual budget of close to 1.4 billion euros – which provides our students and researchers with virtually unlimited possibilities for exchange and resources for development.

Research at UA Ruhr is developing at a rapid pace. By bundling the complementary strengths of our partner universities, we successfully open up innovative research fields. With joined forces, we thus form critical masses in terms of personnel and infrastructure that are indispensable for handling large research topics.

Outstanding examples of that standard-setting collaboration include the Flagship Programs Materials Chain and Ruhr Explores Solvation (RESOLV), set up in 2015, where numerous researchers from the UA Ruhr universities work hand in hand, often in cooperation with other third-party and international partners. The research cluster RESOLV is financed by the DFG Excellence Initiative.

Moreover, 100 additional joint research institutions and projects have been established spanning all disciplines, from American studies to cell biology.

One of our strengths is nurturing young talent. Research Academy Ruhr is one of the largest and most powerful platforms in Germany to support young researchers and prepare them for careers inside and outside academia. Research Academy Ruhr is sponsored and supported by the three UA Ruhr universities and is instrumental for the development of UA Ruhr as academic location.

To support our already strong global network of international exchange and collaboration, the University Alliance established liaison offices. The Liaison Office Moscow is in charge of the cooperation with Russia and the region of Eastern Europe and Central Asia and the Liaison Offices New York is responsible for the region of Northern America.

As the Liaison Office Moscow, we represent the three universities of the alliance in Russia as well as Eastern Europe and Central Asia (EECA). It is our mission to facilitate and foster the international academic exchange and collaboration between East and West, and to raise the local profile and visibility of Germany's thriving Ruhr Region as an epicentre for research, science, and innovation. The Liaison Office Moscow is the first, immediate partner for researchers, students and alumni of the university alliance Ruhr (UA Ruhr) interested in Russia and the region of Eastern Europe and Central Asia (EECA). We help those seeking to initiate cooperation and support ongoing projects. We are also the first point of contact for students and researchers coming from Russia and EECA countries who are interested in the many and diverse opportunities offered by the UA Ruhr.

Ministry of Culture and Science of the German State of North Rhine-Westphalia

CONTACT OFFICE OF THE MINISTRY OF CULTURE AND SCIENCE OF THE FEDERAL STATE OF NORTH RHINE-WESTPHALIA

Ekaterina Karpushenkova

Contact Office of the Ministry of Culture and Science of the Federal State of North Rhine-Westphalia

Ministry of Culture and Science of the Federal State of North Rhine-Westphalia has been operating a contact office in Moscow on interuniversity and research cooperation since 2005.

North Rhine-Westphalia (capital city Duesseldorf) is the leading German State not only in economy but also in the field of science and research where innovative ideas become reality. The densest scientific region in Europe with 72 universities and more than 50 non-university research institutions offers the best conditions to find answers to the major social challenges and to open up the markets of tomorrow. For North Rhine-Westphalia these are primarily the markets for new materials, mechanical and plant engineering and production technology, health, information and communications, mobility and logistics, energy and environmental economics, life sciences and the media and creative industries. They have a particularly high potential for the economy and employment and thus have a high priority for the economic development of the state. These topics are also reflected in the content orientation of universities. The close cooperation between an innovative, industrial economy and outstanding research enables a quick transfer of ideas into practice.

The Russian Federation is one of the key countries for North Rhine-Westphalia in the field of international scientific cooperation.

The contact office in Moscow conducts together with its German partner – centre of innovation and technique ZENIT GmbH the project Cooperation Axis North Rhine-Westphalia – the Russian Federation. The requests from relevant universities and research organisations from both sides in the field of science and development of cooperation are being processed and supported in the establishment of bilateral contacts in the Russian Federation and in the state of North Rhine-Westphalia.

The tasks of the contact office of the Ministry of Culture and Science of the Federal State of North Rhine-Westphalia in Moscow are:

- The first contact person for universities and research institutes from Russia and North Rhine-Westphalia;
- Marketing and publicity to promote the state of North Rhine-Westphalia as a centre for innovation and research;
- Representation of North Rhine-Westphalia at conferences, exhibitions, seminars, specialised forums and negotiations;
- Bilateral support in establishing contacts with universities and research institutes;
- Accompanying delegations from North Rhine-Westphalia and Russia in cooperation with ZENIT GmbH;
- Providing information on support programs and initial support for joint projects.

RUSSIAN SCIENCE FOUNATION (RSF)

Dr Alexander Khlunov
General Director of the RSF

With an annual budget of about US$ 350 million (fiscal year 2019), RSF is the excellence-driven premier research funder in Russia providing sufficient financial support for the cutting-edge research projects in all branches of frontier science, including humanities. Scientists and scholars of any nationality and in any discipline can apply to the RSF for a grant to undertake research at the frontiers of knowledge.

Since 2014, more than 6,000 projects have been selected for funding, engaging 34,300 researchers, including 23,300 young scientists, from 578 host organisations nationwide. Some 12,000 articles acknowledging RSF support were published in highly reputable international journals in 2018. At least half of each research team funded by the RSF are the young scientists aged under 39, which contributes to the training of a new generation of excellent researchers in Russia.

Through peer-reviewed competitions the most promising research projects, the best scientists are funded to perform their research in Russia. The recipients of the RSF grants enjoy a stable long-term prospective for their research with all necessary financial support provided for their significant research contribution to the global science as well as to the Russian economy and society.

In a multi-layered review process, each proposal is evaluated by 2 to 5 external reviewers from Russia and abroad exclusively according to scientific merit; on the basis of these review reports, it is assessed by the members of an expert panel, and the final decision is made by an interdisciplinary expert council consisting of members that are regularly rotated by research community on the basis of the on-line voting process.

The rigorous review process involves AI-based toolkit that helps to find appropriate reviewers from internally developed database of 6,000 highly qualified reviewers, including over 1,000 honorary contributors from around the globe representing some 54 countries.

An ambitious presidential program to support early-career researchers was launched by the RSF in the spring 2017. This program resulted during 2017–2019 in awards for 1501 young scientists under the age of 33 (20,000–30,000 euros annually for 2 years with a special relocation bonus) and for 892 youth research groups (40,000–80,000 euros annually for 3–5 years). These youth-support programs became regular funding source provided by the RSF on a yearly basis.

The RSF actively encourages international research cooperation. The Foundation participates in a number of bilateral funding schemes that provide assistance to the outstanding Russian researchers to participate in collaborative research projects with their top international peers based on the principles of excellence, parity funding, credible independent peer-review and mutual trust.

The RSF secured a diversified portfolio of the bilateral collaborations with funders from Germany (DFG, Helmholtz Association), France (ANR), Belgium (FWO), Austria (FWF), Japan (MAFF), India (DST) and Taiwan (MOST). As a result, 83 international collaborative projects were co-funded by RSF in amount of US$ 8 million in 2019.

Since 2016, 54 joint projects have received support under the RSF-DFG funding program.

LIST OF PARTICIPANTS

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54	SCHUSTER, Cosima	Physics and Chemistry, Deutsche Forschungsgemeinschaft (DFG), Bonn
55	SKRYABIN, Nikolay	Quantum Technologies Centre, Faculty of Physics, Lomonosov Moscow State University; Moscow Institute of Physics and Technology
56	SLEDZ, Florian	Laboratory of Nano-Optics, University of Siegen
57	STAUDE, Isabelle	Institute of Applied Physics, Abbe Center of Photonics, University of Jena
58	STEFSZKY, Michael	Department of Physics, University of Paderborn
59	STÜDEMANN, Tobias	Liaison Office of Freie Universität Berlin in Moscow
60	TISHKOV, Vladimir	Ambassador Scientist of Humboldt Foundation; Faculty of Chemistry, Lomonosov Moscow State University
61	URUMYAN, Anna	Representative Office of the State Lower Saxony, Moscow
62	VASKIN, Aleksandr	Institute of Applied Physics, Abbe Center of Photonics, University of Jena
63	WEIDEMANN, Sebastian	Institute of Physics, University of Rostock
64	WEISS, Dieter	Institute for Experimental and Applied Physics, University of Regensburg
65	ZIPFEL, Jonas	Institute for Experimental and Applied Physics, University of Regensburg

PROGRAMME

September 23, Monday

	Arrival of Participants, Transfer to the Hotel, Check-in
17:00–18:30	Panel Discussion of Freie Universität Berlin "Science Diplomacy through Representation?"
19:00	Evening Reception by DWIH Moscow

September 24, Tuesday

10:30	Registration of Participants
11:00	**OFFICIAL OPENING OF THE WEEK** with welcome addresses by Professor Dr **Victor Sadovnichy**, Rector of the Lomonosov Moscow State University (MSU) **Beate Grzeski**, Deputy Head of Mission, German Embassy in Moscow Professor Dr **Frank Allgöwer**, Professor, University of Stuttgart; Vice-President of the German Research Foundation (DFG) Dr **Michael Harms**, Director Communications of the German Academic Exchange Service (DAAD)
11:45–12:30	**OPENING LECTURE** Dr **Maria Chekhova**, Max Planck Institute for the Science of Light, Erlangen "Generation of Entangled Photons without Momentum Conservation" Professor Dr **Andrey Fedyanin**, Lomonosov Moscow State University "Nonlinear and Tunable All-Dielectric Metasurfaces"
13:30	**Lunch Break**

14:30–16:00	**LECTURES: METAMATERIALS** Chair: Professor Dr **Isabelle Staude**, University of Jena Professor Dr **Evgeni Ilichev**, Novosibirsk State Technical University; Leibniz Institute of Photonic Technology, Jena
14:30	Professor Dr **Isabelle Staude**, University of Jena "Light-Emitting Dielectric Metasurfaces"
	Short Lectures of Young Researchers
15:15	**Ilya Fradkin**, Skolkovo Institute for Science and Technology "Light Scattering by Lattices of Resonant Nanoparticles in Dipole Approximation"
15:30	**Anna Fedotova**, University of Jena "Towards Spontaneous Parametric Down-Conversion in Lithium Niobate Metasurfaces"
15:45	Dr **Michael Stefszky**, University of Paderborn "Optical Squeezing from Lithium Niobate Waveguide Resonators"
16:00	Dr **Maria Kroychuk**, Lomonosov Moscow State University "Nonlinear Optical Effects in Isolated Oligomers of Mie-Resonant Nanoparticles Excited by Gaussian and Vector Beams"
16:00	**Coffee Break**
16:30–17:30	**Quantum Technologies: Reality and Prospective** *(Discussion)* Professor Dr **Sergey Kulik**, Lomonosov Moscow State University Dr **Maria Chekhova**, Max Planck Institute for the Science of Light, Erlangen
17:30	**Conference Group Photo**
17:40–18:40	**Visit to the Quantum Technology Centre of Lomonosov Moscow State University** *(by foot)*
	Social Programme (Boat Tour and Dinner)

September 25, Wednesday

09:30–10:30	**LECTURES: SEMICONDUCTOR NANOSTRUCTURES** Chair: Professor Dr **Sergey Kulik**, Lomonosov Moscow State University
09:30	Professor Dr **Dieter Weiss**, University of Regensburg "HgTe Nanowires as Platform to Search for Majorana States"
10:00	Professor Dr **Vladimir Gavrilenko**, Institute for Physics of Microstructures of the RAS, Nizhny Novgorod "Far and Mid IR Stimulated Emission in HgCdTe Quantum Well Heterostructures"

10:30–11:30 **Short Lectures of Young Researchers**

Chair:
Professor Dr **Dieter Weiss**, University of Regensburg
Professor Dr **Vladimir Gavrilenko**, Institute for Physics of Microstructures, Nizhny Novgorod

10:30 Dr **Mikhail Durnev**,
Ioffe Physical-Technical Institute, St. Petersburg
"Photoinduced Edge Current in Systems with Two-Dimensional Electron Gas"

10:45 **Aleksey Kazakov**,
Lomonosov Moscow State University
"Photoinduced Nonlocal Electron Transport in HgCdTe Solid Solutions with Inverted Energy Band Order"

11:00 **Lukas Maczewsky**,
University of Rostock
"Realization of Photonic Anomalous Floquet Topological Insulator"

11:15 **Jonas Zipfel**,
University of Regensburg
"Exciton Propagation in Monolayer Semiconductors"

11:30 **Coffee Break**

12:00–12:30 **LECTURES: PHOTONICS**

Chair:
Dr **Cosima Schuster**, DFG Bonn

Professor Dr **Aleksey Kalachev**,
Kazan Physical-Technical Institute
"Single Photons from Photonic Molecules"

12:30–13:30 **Short Lectures of Young Researchers**

Chair:
Professor Dr **Dieter Weiss**, University of Regensburg
Professor Dr **Aleksey Kalachev**, Kazan Physical-Technical Institute

12:30 Dr **Aleksandra Galeeva**,
Lomonosov Moscow State University
"Terahertz Probing of Electron States in 3D Topological Insulator Materials"

12:45 **Markus Plankl**,
University of Regensburg
"Tracing Light-Matter Coupling on the Nanometer Length- and the Femtosecond Timescale"

13:00 Dr **Assegid Flatae**,
University of Siegen
"Plasmon-Assisted Ultrafast Photodynamics in Quantum Dots"

13:15 **Florian Sledz**,
University of Siegen
"Optical Studies of SiV Color Centers in Phosphorous-Doped Diamond"

13:30 **Lunch Break**

14:30–15:30 **DISCUSSION ROUNDS**

Progress towards Microwave Quantum Engineering
Chair:
Professor Dr **Evgeni Ilichev**, Novosibirsk State Technical University;
Leibniz Institute of Photonic Technology, Jena

Spintronics
Chair:
Professor Dr **Dieter Weiss**, University of Regensburg

Light-Matter Interaction in Nanostructures
Chair:
Professor Dr **Isabelle Staude**, University of Jena

Quantum Memory
Chair:
Professor Dr **Aleksey Kalachev**, Kazan Physical-Technical Institute

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15:30–16:00 **Short Lectures of Young Researches**

Chair:
Professor Dr **Aleksey Kalachev**, Kazan Physical-Technical Institute

15:30 **Nikolai Skryabin**,
Lomonosov Moscow State University
"Femtosecond Laser Writing Technology for Intergrated Quantum Photonics"

15:45 **Dmitry Akatyev**,
Kazan Physical-Technical Institute
"Generation of Time-Bin Qudit Based on Spontaneous Parametric Down-Conversion"

16:00 Presentations of the Supporting Organisations of the DWIH (Deutsches Wissenschafts- und Innovationshaus / German Centre for Research and Innovation, DWIH Moscow)

Dr **Andreas Hoeschen**, DWIH Moscow

16:15–18:00 **Coffee Break and Science Café**

Presentation of the Funding Programmes of German and Russian Funding and Research Organisations:

German Research Foundation (DFG)
German Academic Exchange Service (DAAD)
German Russian Chamber of Commerce (AHK)
Freie Universität Berlin (FU Berlin)
The Helmholtz Association
Representative of the Ministry of Culture and Science of the German State of North Rhine-Westphalia in Russia
Representative Office of the State Thuringia
Fraunhofer-Gesellschaft
Representative Office of the State Lower Saxony
Alexander von Humboldt Foundation
University Alliance Ruhr (UA Ruhr)
Centre of Quantum Technologies
Russian Science Foundation (RSF)
Russian Foundation for Basic Research (RFBR)

September 26, Thursday

09:30–10:30 **LECTURES: PHOTONICS**

Chair:
Professor Dr **Nicolas Joly**, University of Erlangen-Nürnberg

09:30 Professor Dr **Mario Agio**,
University of Siegen
"Ultrafast Coupling of Light with Quantum Emitters"

10:00 Professor Dr **Evgeni Ilichev**,
Novosibirsk State Technical University; Leibniz Institute of Photonic Technology, Jena
"Quantum Metamaterials Composed of Superconducting Flux Qubits"

10:30 **Coffee Break**

10:30–12:30 **Market Place / Posters for further discussions**

Chair:
Professor Dr **Mario Agio**, University of Siegen

Dr **Aleksandra Gartman**,
Lomonosov Moscow State University
"Optical Metasurfaces and Integral Photonic Structures for Control of Nonclassical Light on Subwave-Scale"

Susanne Candussio,
University of Regensburg
"Terahertz Radiation Induced Edge Currents in Graphene in the Quantum Hall Regime"

Aleksandr Vaskin,
University of Jena
"Manipulation of Quantum Dots Photoluminescence with Resonant Dielectric Nanostructures"

Alessandro Ferreri,
University of Paderborn
"Multimode Four-Photon Hong-Ou-Mandel Interference"

Gregor Oelsner,
Leibniz Institute of Photonic Technology, Jena
"Optically Pumped Magnetometers – Quantum Sensors for a Variety of Applications"

Maksim Rakhlin,
Ioffe Physical-Technical Institute, St. Petersburg
"Single-Photon Sources at 200 K Based on a CdSe Quantum Dot in a Photonic Nanowire"

And All Young Researchers with Presentations

12:30 Funding Opportunities for Early Career Researchers
Chair:
Dr **Cosima Schuster**, DFG Bonn

Dr **Astrid Evers**, DFG, Bonn
Nadezhda Krasikova, DAAD, Moscow

13:00–13:30 **Short Lectures of Young Researches**

Chair:
Professor Dr **Evgeni Ilichev**, Novosibirsk State Technical University;
University of Jena

13:00 **Sergey Samoylenko**,
Lomonosov Moscow State University
"Evaluation of the Possibility of Dynamic Phase Holograms Usage for Single Atom Arrays Reconfiguration"

13:15 **Max Ehrhard**,
University of Rostock
"Realizing 3D Random Walks of Correlated Photon Pairs"

13:30 **Lunch Break**

14:30–17:30 **LECTURES: QUANTUM OPTICS**

Chair:
Dr **Cosima Schuster**, DFG, Bonn

14:30 Professor Dr **Nicolas Joly**,
University of Erlangen-Nürnberg
"Racing to Triplet States. The Fibres Are under Pressure"

15:00 Professor Dr **Sergey Kulik**,
Lomonosov Moscow State University
"Quantum Computation Based on Photonic Chips and Trapped Neutral Atoms"

15:30 Coffee Break

16:00–17:00 **Short Lectures of Young Researchers**

Chair:
Professor Dr **Nicolas Joly**, University of Erlangen-Nürnberg
Professor Dr **Sergey Kulik**, Lomonosov Moscow State University

16:00 **Anatoly Shukhin**,
Kazan Physical-Technical Institute
"Single Photon and Entangled Photon Pair Generation Using Tapered Optical Fibers"

16:15 Dr **Sascha Agne**,
Max Planck Institute for the Science of Light, Erlangen
"Nonlinear Polarimetry with Parametric Down-Conversion"

16:30 **Sebastian Weidemann**,
University of Rostock
"Non-Hermitian Quantum Walks in Coupled Optical Fiber Loops"

16:45 **Jano Gil Lopez**,
University of Paderborn
"Orchestrating PDC Temporal Modes"

17:00 **Coffee Break and Cooperation Workshop**

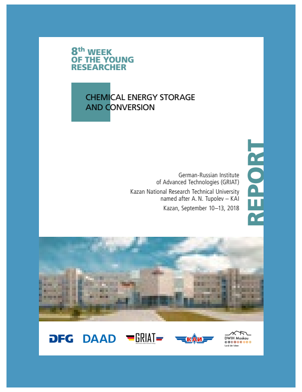
Anna Savostina, DWIH

18:00 Closing Remarks
Professor Dr **Sergey Kulik**

ARCHIVE OF PUBLICATIONS

QUANTUM SCIENCE: LIGHT-MATTER INTERACTION
2019, Moscow

CHEMICAL ENERGY STORAGE AND CONVERSION
2018, Kazan



COMPUTATIONAL BIOLOGY AND BIOMEDICINE
2017, Skolkovo, Moscow

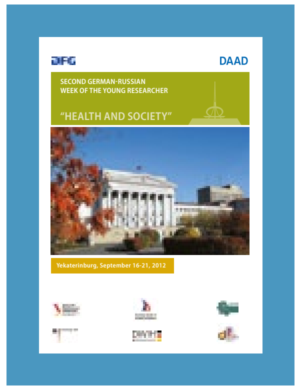
URBAN STUDIES: THE CITY OF THE FUTURE
2016, Moscow

DISCRETE GEOMETRY
2015, Moscow

GLOBAL HISTORY
2014, St. Petersburg

AVIATION AND SPACE
2013, Novosibirsk

HEALTH AND SOCIETY
2012, Yekaterinburg



MAN AND ENERGY
2011, Kazan