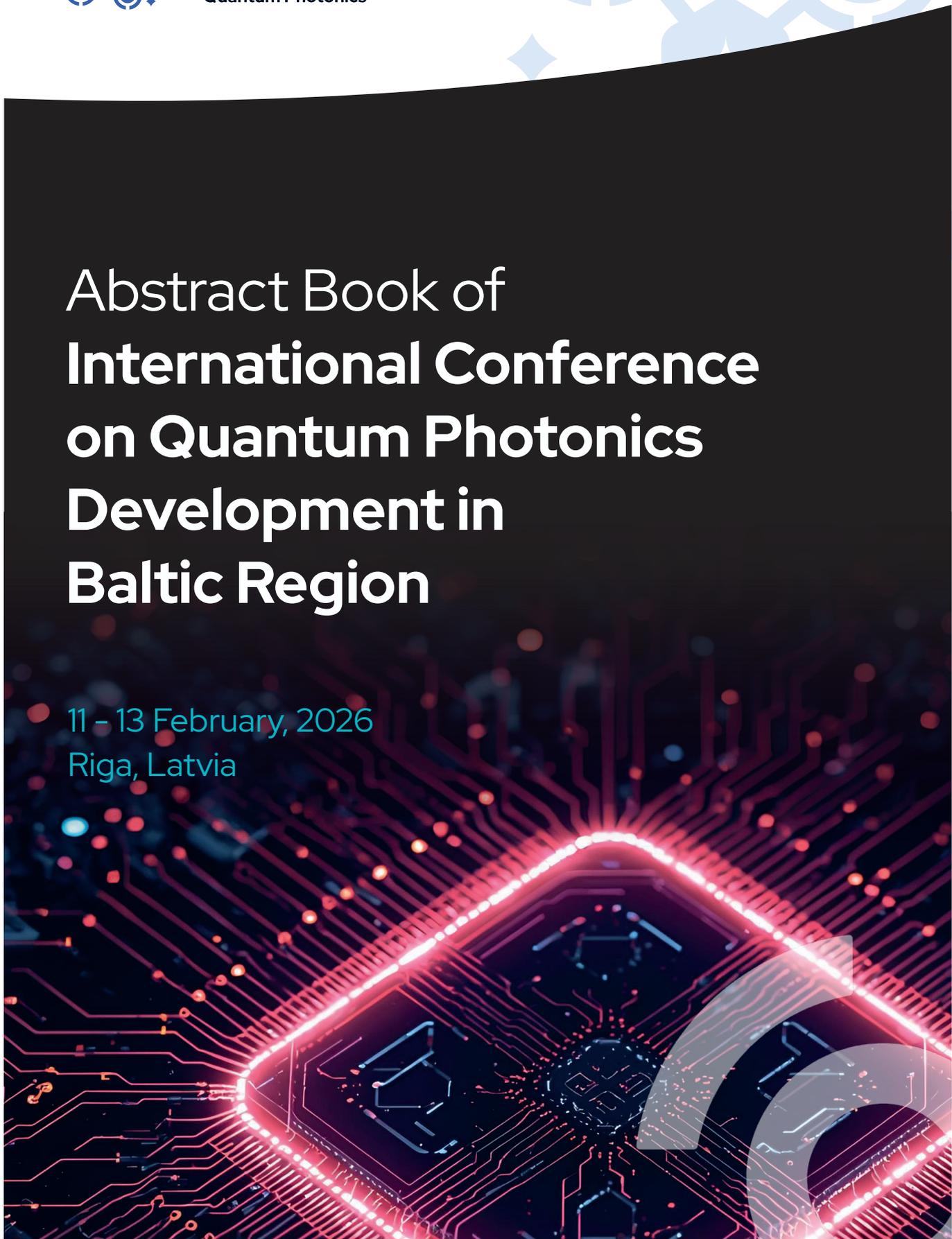




ToEQPL
Quantum Photonics

Abstract Book of International Conference on Quantum Photonics Development in Baltic Region

11 - 13 February, 2026
Riga, Latvia



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Invited speakers

Prof. Christoph Becher

University of Saarland

Telecom interfaces for color centers in diamond

Prof. Ruth Oulton

University of Bristol

Quantum Dots for Second Generation Quantum Computing

Prof. Philip Walter

University of Vienna

Quantum Photonics for Quantum Computing and Machine Learning

PhD Maja Colautti

European Laboratory for Non-Linear Spectroscopy

Enhanced control of organic molecules for quantum photonic technologies

Prof. Artūrs Medvids

Riga Technical University

Quantum Cone - Nano Source of Light with Dispersive Spectrum: Technology and Properties

Hani Barhum

Triangle Research and Development Center

Birefringent Spherulite Optomechanics for Dual Quantum pH and Magnetic Bio-Sensing

Pavel Ginzburg

Tel Aviv University

Theranostic Metamaterials with Quantum Sensors

Anna Baldycheva

University of Exeter

From Materials to Devices: Graphene and 2D Materials for Photonic Platforms

Svitlana Matsenko

Technical University of Denmark - DTU

ML-Enabled Mode Mismatch Mitigation in CV-QKD under DSP Constraints

Jacopo Secco

Politecnico di Torino

Chaotic low power implementations for encryption applications

Ilya Goykhman

The Hebrew University of Jerusalem

Exciton manipulation and confinement in 2D semiconductors

Eugenio Maggolini

Johannes Kepler University Linz, Austria

Quantum nonlinear optics in exciton-polariton circuits

Dmytro Vovchuk

Riga Technical University

Post-Quantum Chaos Synchronization-based Protocol for Secure Communication

Janis Alnis

University of Latvia, Optical,

Electrodynamic and magnetic levitation of microspheres and microdroplets as candidates for whispering gallery mode resonators

Rihards Mūrnieks

Riga Technical University

Realization of Long-Distance Quantum-Memory Enhanced Entanglement Distribution Network in Latvia

Juan Loredo

Sparrow Quantum

Deterministic quantum dot based photon-emitter technology

Conference program

Wednesday, February 11th, 2026

Time	Speaker / Event	Topic	Chair
8:30 – 9:00	Registration		
9:00 – 9:10	Conference opening		
9:10 – 9:30	Aivars Vembris	ToEQPL project	
9:30 – 10:50	Presentation session: Quantum photonics materials and technologies		Aivars Vembris
9:30 – 10:05	Maja Colautti	Enhanced control of organic molecules for quantum photonic technologies	
10:05 – 10:40	Ruth Oulton	Quantum Dots for Second Generation Quantum Computing	
10:40 – 11:10	Coffee break		
11:10 – 13:15	Presentation session: Quantum photonics materials and technologies		Aivars Vembris
11:10 – 11:45	Eugenio Maggolini	Quantum nonlinear optics in exciton-polariton circuits	
11:45 – 12:20	Artūrs Medvids	Quantum Cone - Nano Source of Light with Dispersive Spectrum: Technology and Properties	
12:20 – 12:55	Ilya Goykhman	Exciton manipulation and confinement in 2D semiconductors	
12:55 – 13:15	Lorenzo Pavesi	Spectrally Separated Twin Photons on Silicon for Ghost and Undetected-Photon Sensing	
13:15 – 14:15	Lunch		
14:15 – 16:20	Presentation session: Integrated Quantum Photonics		Lorenzo Pavesi
14:15 – 14:50	Philip Walther	Quantum Photonics for Quantum Computing and Machine Learning	
14:50 – 15:25	Tadas Paulauskas	hBN Emitters and SPDC Sources for Integrated Quantum Photonics	
15:25 – 15:45	Homa Zarebidaki	Silicon Carbide-on-Insulator as an Emerging Platform for Scalable Quantum Photonic Integrated Circuits	
15:45 – 16:05	Arturs Bundulis	Heterogeneous integration of highly nonlinear host-guest organic systems for nonlinear optical applications	
16:05 – 17:30	Poster session/coffee break		

Conference program

Poster session

Wednesday, February 11th, 2026, 16:05 – 17:30

	Poster presenter	Topic
P1	Fatima Zohra Boudjenane	Structural, Electronic, and Nonlinear Optical Properties of Bis(L-Proline) Cadmium Iodide Single Crystal: A Combined XRD and DFT Study
P2	Anete Sapne	Development of host-guest polymer photonic element fabrication for integrated quantum photonics
P3	Gustas Liaugminas	Fiber-Based Source for Polarization-Entangled Photon Pair Generation at Hybrid Network Wavelengths
P4	Kirills Dmitrijevs	Synthesis and Characterization of Organic NLO Chromophores for Integrated Photonics
P5	Lāse Mīlgrāve	Long-term stability of integrated SU-8 polymer ring resonators
P6	Miroslavs Mališko	The analysis of possible quantum technology applications onboard modern ships
P7	Margarita Zommere	Polymeric Pillar Microcavities for Enhanced Single-Photon Emission from Organic Molecules
P8	Kristians Draguns	Tantalum pentoxide microring resonators
P9	Armands Ruduss	Deuteration Strategies for Single-Photon Emitter Molecules
P10	Reinis Lazda	Quantum imaging with undetected infrared light generated by spontaneous parametric down-conversion in nonlinear crystals
P11	Šarūnas Meškinis	Direct Synthesis and Characterization of Graphene/h-BN Layers and Heterostructures for Quantum Applications
P12	Artūrs Mozers	High-order coherences for magnetic field sensing beyond low-field limits
P13	Ziad Abi Akar	NV-Based Spin-Photon Optical Communication

Conference program

Thursday, February 12th, 2026

Time	Speaker / Event	Topic	Chair
8:30 – 9:00	Registration		
9:00 – 10:50	Presentation session/Quantum Communication & Networks		
9:00 – 9:35	Christoph Becher	Telecom interfaces for color centers in diamond	Stefano Azzini
9:35 – 10:10	Jacopo Secco	Chaotic low power implementations for encryption applications	
10:10 – 10:30	Alexandr Belosludtsev	Silver-Aluminium High Mirrors for Space Communication Applications	
10:30 – 10:50	Aleksandrs Gorbunovs	Quantum Technology to Form a New Warfare Domain	
10:50 – 11:20	Coffee break		
11:20 – 13:10	Presentation session/Integrated Quantum Photonics		
11:20 – 11:55	Rihards Mūrnieks	Realization of Long-Distance Quantum-Memory Enhanced Entanglement Distribution Network in Latvia	Arturs Bundulis
11:55 – 12:30	Janis Alnis	Optical, electrodynamic and magnetic levitation of microspheres and microdroplets as candidates for whispering gallery mode resonators	
12:30 – 12:50	Stefano Azzini	CMOS-compatible integrated single-photon sources in the visible to near-infrared spectral region	
12:50 – 13:10	Alessio Baldazzi	A quantum variational silicon photonic solver	
13:10 – 14:10	Lunch		
14:10 – 16:00	Presentation session/Quantum Sensing & Metrology		
14:10 – 14:45	Pavel Ginzburg	Theranostic Metamaterials with Quantum Sensors	Kaspars Traskovskis
14:45 – 15:20	Hani Barhum	Birefringent Spherulite Optomechanics for Dual Quantum pH and Magnetic Bio-Sensing	
15:20 – 15:40	Elias Sfeir	Room-Temperature Magnetic Vortices in the van der Waals Magnet Fe₅GeTe₂ .	
15:40 – 16:00	Mona Jani	Microwave-Free Detection of magnetic nanostructures using zero-field cross-relaxation feature of nitrogen-vacancy centers in nanodiamond	
18:00 – 21:00	Conference diner		

Friday, February 13th, 2026

Time	Speaker / Event	Topic	Chair
8:50 – 9:00	Registration		
9:00 – 10:45	Presentation session/Quantum Communication & Networks		
9:00 – 9:35	Dmytro Vovchuk	Post-Quantum Chaos Synchronization-based Protocol for Secure Communication	Christophe Couteau
9:35 – 10:10	Anna Baldycheva	From Materials to Devices: Graphene and 2D Materials for Photonic Platforms	
10:10 – 10:45	Svitlana Matsenko	ML-Enabled Mode Mismatch Mitigation in CV-QKD under DSP Constraints	
10:45 – 11:15	Coffee break		
11:15 – 12:30	Presentation session/Quantum photonics materials and technologies		
11:15 – 11:50	Juan Loredo	Deterministic quantum dot based photon-emitter technology	Aivars Vembris
11:50 – 12:10	Dharma Permana	Spin-orbit dynamics of optical vector vortices in coherently prepared atomic media with Λ and tripod configuration	
12:10 – 12:30	Christophe Couteau	Quantum optics using colour centres in diamond	
12:30 – 13:30	Lunch		
13:30 – 14:00	Conference closing		

Towards an excellence centre on quantum photonics in Latvia (ToEQPL) project

Aivars Vembris^{1*}, Kaspars Traskovskis², Toms Salgals², Lorenzo Pavesi³, and Couteau Christophe⁴

¹*Institute of Solid State Physics of University of Latvia, Latvia*

²*Riga Technical University, Latvia*

³*University of Trento, Italy*

⁴*University of Technology of Troyes, France*

**aivars.vembris@cfi.lu.lv*

Abstract – Quantum photonics is a rapidly evolving field that has gained significant momentum in recent years. Initially rooted in free-standing optics, the focus has now shifted towards integrated photonics. In line with the European Quantum flagship, Latvia has established its own Quantum Initiative, which encompasses various areas of research, including quantum cryptography, quantum algorithms, quantum electronics, and photonics. Up to now Latvian scientists have made significant contributions in the fields of quantum algorithms and quantum electronics meanwhile photonics is an established field within the Latvian institutions as Institute of Solid State Physics of University of Latvia (ISSP UL) and Riga Technical university. However, it is important to note that quantum photonics in Latvia is still in its nascent stages of development.

To foster the development of the quantum photonics field in Latvia and establish an Excellence Centre in quantum photonics in the future, several key components are essential. These include a solid foundation of knowledge in quantum photonics, the cultivation of a new generation of scientists in this field, the provision of adequate financial resources, and the development of a cohesive strategy to create an ecosystem conducive to growth.

The project will result in the developed Roadmap of establishing of Centre of excellence in quantum photonics that includes Latvian position in quantum photonics global market and funding source mapping. Additionally, prepared lectures, organised schools and workshops, educational and training materials will establish a strong knowledge foundation in Latvia, with the potential for expansion across the Baltic States.

Keywords – quantum photonics, excellence center, colaboration

Enhanced control of single-molecules for quantum technologies

M. Colautti¹, M.-A. Zommere², R. Duquennoy¹, S. Landreux³, D. De Bernardis¹,
J. Mony¹, L. Jin⁴, W. Pernice⁴, C. Toninelli¹

¹National Institute of Optics (CNR-INO), Italy

²Institute of Solid State Physics, University of Latvia, Latvia

³Laboratoire Charles Fabry, Institut d'Optique Graduate School, CNRS,

⁴Kirchhoff-Institute for Physics, Heidelberg University, Germany

Abstract – The generation and manipulation of quantum states of light is required for key applications, such as photonic quantum simulation, linear optical quantum computing, quantum communication protocols, and quantum metrology. In this context, I will present our recent advancements in using single organic molecules at cryogenic temperature as bright and stable sources of coherent single photons in the solid state [1]. In particular, I will focus on our results on two-photon interference (TPI) experiments performed between distinct molecules on the same chip [2], and our insights on how to mitigate the practical limitations on the TPI among distinct emitters via the control of the electrical environment at the nanoscale. Indeed, we recently provided experimental demonstration of a hybrid tuning method for controlling the frequency of quantum emitters and at the same time to reduce the emitter sensitivity to charge noise, controlling spectral fluctuations [3]. This successful strategy is based on the combined use of the electric field generated by electrodes and of optically excited long-lived charge states [4], which provide two efficient knobs for enhanced control of single-molecule emitters for quantum photonic experiments. Finally, I will present preliminary result on advanced methods for hybrid integration of single organic molecules into nanophotonic structures.

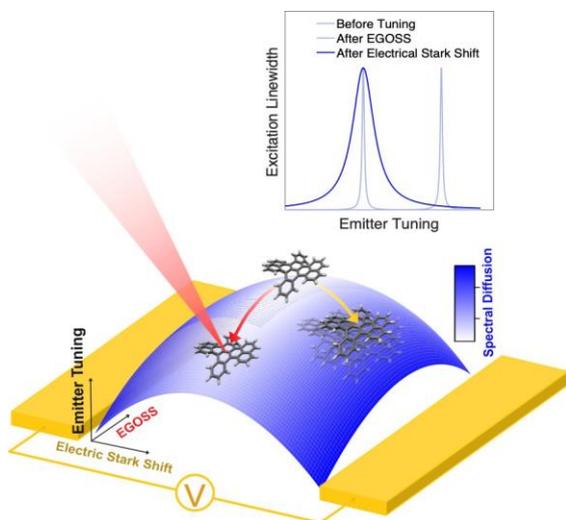


Figure: Dibenzoterrylene-doped nanocrystals of anthracene are dispersed on a glass substrate, nanostructured with 4 μm gap interdigitated gold electrodes. A combination of optical pumping and electrode-generated electric field is implemented (electrically guided optical Stark shift: EGOSS), yielding a high Emitter Tuning degree of control on the local applied field with high spatial resolution and out-of-plane orientation. This allows for a reduction of spectral fluctuation (by a factor of 12) for a given frequency shift, with respect to the case of an in-plane-only electric field manipulation. In this way, the emission frequencies of single molecules can be tuned without degrading their spectral stability.

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- [4] Colautti, M. *et al.*, *ACS Nano* **14** (10), 13584–13592 (2020).

Keywords – Single-Photon Sources, Single Organic Molecules, Spectral Tuning, Control of spectral diffusion, photonic integration

Quantum Dot Spins for Quantum Computing

Ruth Oulton^{*1}, Petros Androvitsaneas¹, David Dlaka¹, Thomas Nutz¹, John M Lennon¹, Samuel Mister¹, Christian Schneider², Martin Kamp³, Sven Höfling³, Dara PS McCutcheon¹, Andrew B Young¹, Edmund Harbord¹, John G Rarity¹

¹ QETLabs, H. H. Wills Physics Laboratory, University of Bristol, Tyndall Avenue, Bristol, BS8 1TL, United Kingdom, and Department of Electrical & Electronic Engineering, University of Bristol, BS8 1FD, United Kingdom

² Institute of Physics, University of Oldenburg, D-26129 Oldenburg, Germany

³ Technische Physik, Physikalisches Institut and Wilhelm Conrad Röntgen-Center for Complex Material Systems, Universität Würzburg, Am Hubland, 97474 Würzburg, Germany

^{*}(ruth.oulton@bristol.ac.uk)

Abstract – Quantum dots, nanoscale semiconductors, are capable of acting as artificial atomic light emitters. Their use as an efficient and high rate single photon source is beginning to find commercial applications in all areas of quantum technologies. However, they are not yet seen as a frontrunner platform for photonic quantum computing. I will discuss the progress that has been made in QD devices so far, including in my own group, the essential progress still needed to meet the stringent requirements of quantum computing, and give my thoughts on the path to achieve this.

Keywords – quantum dots, entanglement, quantum computing, cluster states, spins

Structural, Electronic, and Nonlinear Optical Properties of Bis(L-Proline) Cadmium Iodide Single Crystal: A Combined XRD and DFT Study

Eugenio Maggiolini ^{1, 2, 3}

¹ *Institute of Semiconductor Physics, Johannes Kepler University Linz, 4040 Linz, Austria*

² *CNR Nanotec, 73100 Lecce, Italy*

³ *Dipartimento di Fisica, Università di Pavia, 27100 Pavia, Italy*

Abstract – Exciton-polaritons in III-V semiconductors, thanks to their photonic component, can in principle approach significant coherence times when operated at low temperature and have shown the ability to be prepared from non-classical states of light retaining non-classical features as entanglement [1]. At the same time, from the excitonic component they can inherit significant Kerr-like interactions, which can overcome the limit of non-deterministic operation typical of purely photonic quantum computing approaches. Nevertheless, despite the potential for quantum information, exciton-polariton interactions have been mostly studied at mean-field levels, where screening effects can reduce their strength and bath-related effects can obscure quantum dynamics. We thus find it a compelling task to fully characterize polariton-polariton interactions at the true single-particle level. We pick planar polaritonic circuits as the most interesting setting for our investigation. Contrary for instance to microcavities, waveguides can offer perspective flexibility in implementing complex functionalities as interference devices, on-demand dispersion engineering with photonic crystals, neural networks or strategies for the external modulation of exciton interactions [2]. We also find it essential to switch from classical measurement approaches that rely on intensity and phase observables [3], to experiment designs based on correlation statistics, as proposed in [4]. At the same time, we need to pursue improved nanofabrication and design approaches to mitigate decoherence and losses, which in III-V materials can differ significantly from the state-of-the-art of silicon photonics.

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Quantum Cone - Nano Source of Light with Dispersive Spectrum: Technology and Properties

*Arturs Medvids¹, Patrik Ščajev², Saulius Miasojedovas², Kazuhiko Hara³

¹ Institute of Technical Physics, Riga Technical University, Paula Valdena 3/7, LV 1048 Riga, Latvia

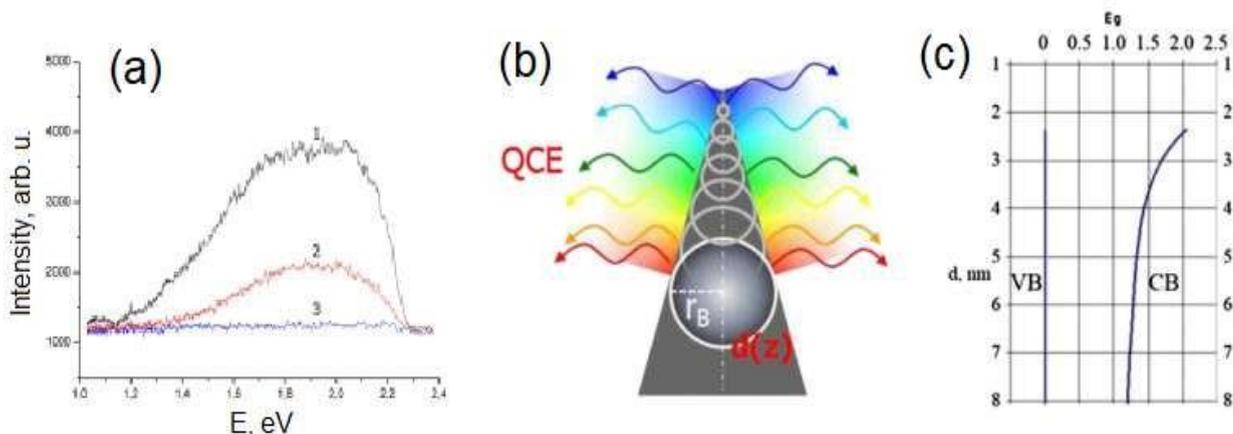
² Institute of Photonics and Nanotechnology, Faculty of Physics, Vilnius University, Sauletekio Ave. 3, 10257 Vilnius, Lithuania

³ Research Institute of Electronics, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu 432-8561, Japan

*medvids@latnet.lv

Abstract – Nanostructures are the most investigated objects in solid-state physics, especially the Quantum confinement effect in quantum dots – 0D, quantum wires - 1D, and quantum wells – 2D systems. Under these conditions, constructing new electronic and optical devices is possible. We showed the possibility of the formation of a new quantum system, the so-called Quantum cone (QC), on the surface of Ge, Si, CdTe, and DLC crystals by laser radiation. The QC possesses unique optical properties: a huge “blue shift” of photoluminescence (PL) spectrum on 1.1 eV (Fig a) with increased intensity more than a million times, and “redshift” of LO phonon line frequency in Raman spectrum is evidence of QC formation. Irradiation of SiO₂/Si structure by Nd:YAG laser led to the formation of QC, which possesses a unique PL spectrum: “blue shift” of 1.2 eV, an asymmetric, wide band from 1.1 eV to 2.2 eV with gradually decreased intensity in the red part of the spectrum, rainbow-like spectrum (Fig. b). These properties of the system of PL spectrum are typical for graded bandgap semiconductors (Fig.c). The quantum cone with a solid angle less than 60° is a 1D quantum system with a gradually decreasing diameter from the base to the top of the cone. These facts speak in favour of the possibility of a gradual decrease in the lifetime of excitons from the base to the top of a cone. This study aims to show that QC is a nano source of light with a dispersive and fast-changing spectrum. The PL kinetics of DLC samples formed by magnetron sputtering were studied. The kinetics of the PL spectrum is described by a stretched exponential. The parameters of the QC as nano sources of light are: the linear dispersion $dh/d\lambda = 0.1$, and the rate of spectra $V_\lambda = 3 \times 10^{10}$ nm/s.

Keywords – Quantum Cone, Nano Source of Light, Dispersive Spectrum, Laser, Si, Ge, DLC, Kinetics of the PL Spectrum



Exciton manipulation and confinement in 2D semiconductors

Ilya Goykhman

Institute of Applied Physics, The Center for Nanoscience and Nanotechnology, The Hebrew University, Jerusalem, Israel.

**ilya.goykhman@mail.huji.ac.il*

Abstract – The rich portfolio of 2D materials and favorable heterogeneous integration with photonic integrated circuits set up new horizons for hybrid on-chip optoelectronics and quantum photonics. In this talk, I will discuss exciton manipulation in atomically thin 2D semiconductors and the development of advanced 2D tunable excitonic light-emitting diodes for on-chip integration and single-photon sources. I will present key aspects of material properties, device physics, nanofabrication, and system performances.

Keywords – 2D materials, excitons, dielectric-environment, light-emitting diodes, single photon emitters

Spectrally Separated Twin Photons on Silicon for Ghost and Undetected-Photon Sensing

Chiara Michelini^{1,2}, Stefano Signorini^{1,3}, Lorenzo Pavesi¹

¹Nanoscience Laboratory, Department of Physics, University of Trento, Trento, Italy

²Innovation Hub, Quantum Technologies Lab, Via Tiburtina, km 12,400, 00131 Rome, Italy

³ICFO-Institut de Ciències Fotoniques, The Barcelona Institute of Science and Technology, Castelldefels (Barcelona), Spain

*(lorenzo.pavesi@unitn.it) Email of the corresponding author

Abstract – Intermodal spontaneous four-wave mixing (SFWM) in multimode silicon-on-insulator waveguides provides a compact source of spectrally separated twin photons for mid-infrared (MIR) quantum sensing. By pumping with a standard telecom laser and exploiting the dispersion of transverse-electric TE₀/TE₁ modes, we generate highly non-degenerate photon pairs in discrete emission bands, enabling broadband pump rejection and efficient on-chip mode-based separation of idler and signal. We first demonstrate heralded MIR single photons with an idler at 1259.7 nm and a signal at 2015 nm, detected via upconversion, achieving a heralded $g^{(2)}(0)=0.23$ and a coincidence-to-accidental ratio up to 40.4. Building on the same platform, we perform ghost spectroscopy of gaseous CO₂ around 2 micrometers: the MIR photon probes the sample while the near-infrared partner is spectrally analyzed, and coincidences between the two detections suppress strong, time-varying background, yielding a sensitivity $S=(5.7\pm 0.1)\times 10^{-2} \text{ (g/L)}^{-1}$, higher than a classical measurement under identical conditions. Finally, we integrate an undetected-photon measurement on chip by cascading two intermodal-SFWM sources in a low-gain SU(1,1) interferometer. A phase applied to the undetected signal at 1972 nm is retrieved by measuring only the correlated idler at 1291 nm, enabling MIR phase and refractometric sensing without MIR detectors. These results highlight transverse-mode engineering as a route to scalable, low-cost MIR quantum metrology.

Keywords – intermodal four-wave mixing; highly non-degenerate photon pairs; silicon quantum photonics; ghost spectroscopy; undetected-photon metrology; mid-infrared sensing

Exploiting Quantum Photonics for Quantum Computing and Machine Learning

Philip Walther^{1, 2, *}

¹ *University of Vienna, Faculty of Physics, Vienna Center for Quantum Science and Technology (VCQ), Boltzmannngasse 5, 1090 Vienna, Austria*

² *Institute for Quantum Optics and Quantum Information (IQOQI) Vienna, Austrian Academy of Sciences, Boltzmannngasse 3, 1090 Vienna, Austria*

**(walther-office@univie.ac.at)*

Abstract – After providing a brief overview of recent advancements in the generation and processing of multi-photon states [1], I will show the potential of photonic quantum machine learning. After presenting a quantum-enhanced reinforcement learning using a tunable integrated processor [2], I will discuss our development of a so-called quantum memristor for single photons [3]. These devices, which can mimic the behavior of neurons and synapses, hold great promise for the realization of quantum neural networks. I will also present how photonic processors can implementing quantum-enhanced kernels for machine learning tasks [4].

At the end I will change topic by briefly discussing the flexibility of photonic systems for tasks that require non-standard quantum computer architectures [5]; and potentially update about our ongoing experimental research aiming to explore the interface between quantum mechanics and general relativity by performing high-precision experiments using entangled photon states as probe[6].

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Keywords – quantum photonics, quantum information processing, quantum computing, quantum machine learning

hBN Emitters and SPDC Sources for Integrated Quantum Photonics

Tadas Paulauskas*, Edgaras Markauskas, Julius Janušonis, Danielis Rutkauskas

Center for Physical Sciences and Technology, Vilnius, Lithuania

*(tadas.paulauskas@ftmc.lt) Email of the corresponding author

Abstract – We present an overview of quantum photonics research at the Center for Physical Sciences and Technology (FTMC). Our work details the site-selective creation of single-photon sources in hexagonal boron nitride (hBN) using femtosecond laser pulses and ion implantation. These emitters exhibit high brightness and stability at room temperature, with spectral coverage across the visible and NIR ranges. In parallel with these deterministic solid-state sources, we discuss our collaborative efforts with industry partners to develop miniaturized, Sagnac-based spontaneous parametric down-conversion (SPDC) sources. These compact modules are engineered for high-brightness photon pair generation in the visible-NIR spectrum, targeting portable quantum communication applications. To provide a scalable integration platform, we further highlight our research into the fabrication of low-loss optical waveguides in glass substrates via femtosecond laser direct writing. By combining high-purity hBN emitters, efficient SPDC sources, and versatile 3D waveguiding architectures, this work addresses the general challenges of component miniaturization and system compatibility within the Baltic region's growing quantum ecosystem. This broad-spectrum approach aims to facilitate the transition from fundamental research to practical, integrated quantum photonic technologies for future secure communication networks.

Keywords – hBN emitters, SPDC sources, integrated photonics, femtosecond laser writing, quantum communications

Silicon Carbide-on-Insulator as an Emerging Platform for Scalable Quantum Photonic Integrated Circuits

Homa Zarebidaki^{*1}, Alberto Della Torre¹, Mattia Orvietani¹, Florian Dubois¹, Jacopo Leo¹, Dorian Herle¹, Olivier Dubochet¹, Sylvain Nicolay¹

¹Swiss Center for Electronics and Microtechnology (CSEM), Neuchâtel, Switzerland
^{*}(homa.zarebidaki@csem.ch)

Abstract – Silicon carbide (SiC) has recently emerged as a compelling material platform for quantum photonic integrated circuits (Q-PICs), uniquely positioned at the intersection of silicon, central to CMOS technologies, and diamond, renowned for hosting high-quality quantum emitters. By combining advantages from both domains, SiC offers a rare combination of CMOS compatibility and intrinsic quantum functionality. It hosts stable color centers that can act as single-photon sources, supports extremely low acoustic losses enabling high-Q \times f mechanical modes, and provides strong second- and third-order optical nonlinearities. Furthermore, the presence of the Pockels effect allows efficient electro-optic modulation, and the availability of thin SiC-on-insulator (SiCOI) wafers enables truly monolithic, scalable integration. At CSEM, we leverage extensive expertise in bulk SiC etching, along with our long-standing development of thin-film lithium niobate (TFLN) PIC technology, to establish SiC as our next-generation quantum photonic platform. Recent process improvements have enabled propagation losses below 1 dB/cm, as well as fast tunability in the GHz range. In addition, the exceptional optomechanical properties of SiC allow the realization of ultra-clean optical filtering and hybrid photonic–phononic functionalities. This combination of material advantages and fabrication maturity positions SiC as a uniquely powerful platform for integrated quantum technologies, spanning single-photon generation, high-speed modulation, nonlinear quantum optics, and coherent optomechanics. Our progress highlights SiCOI’s potential to drive robust, scalable Q-PIC architectures for quantum communication, sensing, and computation.

Keywords – SiC-on-Insulator (SiCOI); Quantum Photonic Integrated Circuits (Q-PICs); Color Centers; Electro-Optic and Nonlinear Photonics; Ultrapure filter

Heterogeneous integration of highly nonlinear host-guest organic systems for nonlinear optical applications

Arturs Bundulis*, Anete Sapne, Ksenija Bobrovnika and Aivars Vembris

¹Institute of Solid State Physics, University of Latvia, Latvia

**arturs.bundulis@cfi.lu.lv*

Abstract – Heterogeneous integration has emerged as the main strategy for advancing integrated photonic technologies, enabling the combination of various material platform on a single chip. However, further expansion of device functionality through incorporation of emerging material platforms in most cases demands unique platform-specific process, increasing fabrication complexity. While the integration of laser sources and electro-optical switches has been successfully demonstrated using III-V semiconductors and thin-film niobate, expanding to frequency comb integration and quantum photonics demands even more material integration. This is an integral limitation of inorganic photonic platforms.

Polymer-based host-guest systems present an alternative approach in which photonic device fabrication and functional properties are decoupled. Fabrication process is defined by the host material, while the optical functionalities comes from the guest material. Organic materials provide access to a broad and versatile library of dyes suitable for wide range of applications – laser emission, electro-optical modulation, Kerr combs and others. Importantly, integration of new organic dyes does not require substantial changes to the fabrication process.

In this work, we present a framework for an active polymer photonic platform based on host–guest organic systems. The framework includes a comprehensive investigation of the nonlinear optical properties of organic dyes and their potential for quantum photonic applications. Organic dyes exhibit exceptionally high nonlinear optical responses, with Kerr nonlinear coefficients on the order of 10^{-15} - 10^{-16} m²/W, making them particularly attractive for nonlinear and frequency-comb-based devices.

The photonic element fabrication is based on two complementary approaches. First, direct laser writing is employed for organic dyes that are stable under UV exposure, enabling flexible and precise structuring. Second, inkjet printing is used for localized device fabrication within pre-defined trench structures, allowing selective material placement and functional customization.

Keywords – Integrate photonics, Nonlinear optics, Organic materials, Polymer photonics, Kerr effect

Towards quantum networks: telecom interfaces for color centers in diamond

Christoph Becher^{*,1,2}

¹*Fachrichtung Physik, Universität des Saarlandes, Saarbrücken, Germany*

²*Center for Quantum Technologies (QuTe), Universität des Saarlandes, Saarbrücken, Germany*

**christoph.becher@physik.uni-saarland.de*

Abstract – We present emission of highly indistinguishable single photons from a single SnV center in diamond and high-efficiency quantum frequency conversion of the photons to the telecom C-band. The availability of highly indistinguishable visible and telecom photons from a spin qubit represents a significant step toward the realization of a spin-photon interface, a crucial component for quantum repeaters and scalable quantum networks.

Color centers, Diamond, Indistinguishable Photons, Quantum Frequency Conversion, Quantum Networks

For many applications in the field of quantum information processing stationary qubits are required, providing long-lived spin coherence and suitable level schemes for coherent control and efficient optical read out. In addition, transferring the spin information to indistinguishable single photons is necessary e.g. to distribute entanglement in quantum networks. Eventually, the communication wavelength should fall within the low-loss telecom bands, which typically requires quantum frequency conversion of the single photons.

Color centers in diamond, more specifically the group-IV-vacancy centers, have emerged as promising candidates among solid state qubits. Recent experiments have shown that the negatively charged tin-vacancy center (SnV) [1] combines long spin coherence times at conveniently achievable cryogenic temperatures (>1K) [2-6] with truly lifetime-limited transition linewidths down to 20 MHz [1]. Using a strained SnV center at temperatures < 1K, electron spin coherence times under dynamical decoupling reach 10 ms [5] and coherence times of a nearby, hyperfine-coupled ¹³C nuclear spin > 1s [6]. The excellent optical coherence of SnV centers gave rise to demonstrations of photon indistinguishability with *raw* visibilities in Hong-Ou-Mandel interference experiments of $V = 0.56$ for subsequently emitted photons of the same SnV center [7] and $V = 0.8$ for photons from two independent emitters [8].

We here present emission of consecutively emitted, highly indistinguishable single photons from a single SnV center. Using resonant π -pulse excitation, confocal cross-polarization suppression of the excitation laser, and temporal gating of the detection events we observe *raw* Hong-Ou-

Mandel visibilities exceeding 97% (for detecting 99% of the single photon pulse area), mainly limited by residual laser leakage. We furthermore demonstrate quantum frequency conversion [9] of the indistinguishable SnV photons from the 619 nm source wavelength to the telecom C-band with a device efficiency of 45% (at 8 GHz filter bandwidth) and very low noise < 5 photons/s/GHz. The converted telecom photons still exhibit high indistinguishability with *raw* visibility $V > 0.92$ (for detecting 99% of the single photon pulse area), where the limiting factor is the high dark count rate of the telecom superconducting single photon detectors.

The generation of highly indistinguishable visible and telecom photons from a spin qubit in diamond represents a significant step toward the realization of a spin-photon interface, a crucial component for quantum repeaters, scalable quantum networks and the generation of cluster states for photonic quantum computing.

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Chaotic low power implementations for encryption applications

Rosanna Cavazzana ¹, Fernando Corinto ¹ and Jacopo Secco ^{1*}

¹*Department of Electronics and Telecommunications, Politecnico di Torino, Italy*

**(jacopo.secco@polito.it) Email of the corresponding author*

Abstract – Image encryption provides a dependable way to protect information sent across public, unprotected networks. Due to their nonlinear, sensitive dynamics, chaotic systems are increasingly used to build cryptographic primitives. We propose a hardware based generator of pseudorandom sequences that uses a compact, low cost circuit replicating the logistic map behavior, offering a small footprint suitable for embedded devices. A standard microcontroller conditions the raw chaotic time series, binarizes it into streams with an even proportion of zeros and ones, and then selects codes that are mutually orthogonal by computing pairwise cross correlation metrics. The obtained binary sequences pass every test in the NIST SP 800-22 statistical suite, with success rates reaching 99.6%. We also describe how this hardware generator can be incorporated into an image encryption pipeline tailored to secure clinical communications and telemedicine exchanges. Exploiting the distinctive characteristics of the chaotic codes, we implement a DNA inspired image cipher that supports strong confusion and diffusion while remaining lightweight. Robustness is evaluated on four clinical images of skin ulcers, one per severity class according to the Wound Bed Preparation standard. An automated classification workflow verifies that encryption followed by decryption preserves the diagnostic content of the images. Furthermore, six additional security and robustness assessments are successfully satisfied, confirming resistance to common statistical and differential attacks. Overall, the proposed approach offers an economical hardware solution that can be embedded in standard communication platforms, strengthening security and enabling novel data protection methods in clinical settings.

Keywords – Chaos, logistic map circuit, balanced and mutually-orthogonal binary codes, image encryption, chaos-based data encryption, DNA-based coding

Silver-Aluminium High Mirrors for Space Communication Applications

A. Belosludtsev^{*1}, I. Bitinaitis¹, K. Stravinskas¹, V. Kovalevskij¹ and A. Sytchkova²

¹*Center for Physical Sciences and Technology, Lithuania,*

²*ENEA Casaccia, Italy*

**Alexandr.Belosludtsev@ftmc.lt*

Abstract – The volume of information necessary to transmit on Earth, in space, and between satellites and ground stations is increasing. Satellites are planned to be connected to the global secured quantum network on low-Earth orbits, to be used for quantum communication at higher distances from our planet. Such applications require optical components like metallic mirrors for signal preparation and transfer. In recent study [1], we report a systematic investigation on the silver-aluminium (Ag-Al) mixed mirrors designed for space missions. We show the Ag-Al mixed coatings preparation process and investigate their properties for various Al concentrations up to 15%. It was found that optimize Al admixing leads to the formation of smooth mirrors with high reflectance (measured >90% vis-IR range). Mirrors were tested by low-energy proton irradiation at doses typical for interplanetary missions. Furthermore, we have coated an additive manufactured complex shaped mirror [2]. The performance under high-power laser irradiation was numerically studied.

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Acknowledgment

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Keywords – Metal mirrors; Thin films; Radiation tests; Space Optics; Quantum communication.

Quantum Technology to Form a New Warfare Domain

Aleksandrs Gorbunovs*

Institute of Digital Humanities, Faculty of Computer Science, Information Technology and Energy, Riga Technical University, Latvia

**(aleksandrs.gorbunovs_1@rtu.lv)*

Abstract – Rapid advancements in technology are occurring continuously across the globe. The introduction of new scientific discoveries, innovations, and related products and services has accelerated exponentially, particularly during the era of Industry 4.0. Humanity is undergoing a comprehensive integration of the latest technologies, resulting in a convergence of physical, digital, and biological domains – creating the unified, complex, and dynamic systems.

Quantum technologies are recognized not only as a critical component of Industry 4.0 but also as one of the most significant technologies expected to shape future Industry 5.0. Historically, the most advanced technologies are often first deployed within military sectors to enhance defense and combat capabilities. This strategic approach serves multiple purposes, including maintaining economic and military superiority, as well as addressing challenges related to technology adoption such as high costs, technological requirements, compatibility and interoperability issues.

It is reasonable to anticipate similar patterns of development and adoption for quantum technologies. However, an analysis of existing scientific literature reveals limited information regarding their application in military contexts, despite a greater volume of research concerning civilian uses.

The purpose of this report is to examine the strategic approaches adopted by various countries in developing and integrating quantum technologies within military operations, as well as to assess their potential roles and significance in multi-domain operational environments.

Keywords – battlefield; military; multi-domain operations; quantum technology; warfare

Realization of Long-Distance Quantum-Memory Enhanced Entanglement Distribution Network in Latvia

Rihards Mūrnieks^{1,2,*}, Ričards Kudojars^{1,2}, Karīna Prokopoviča^{1,2}, Ints Murāns¹, Jānis Braunfelds^{1,3},
Andis Supe^{1,2}, Xiaodan Pang^{1,2}, Sandis Spolītis¹, Jurgis Poriņš^{1,3}, Vjačeslavs Bobrovs¹

¹*Institute of Photonics, Electronics and Telecommunications, Riga Technical University, Azenes street 12, LV-1048, Riga, Latvia*

²*Quantum Networks and Technology Research Group (RTU QuantumNet), Riga Technical University, Azenes street 12, LV-1048, Riga, Latvia*

³*Fiber Optical Sensor Research Group (RTU FiberSens), Riga Technical University, Azenes street 12, LV-1048, Riga, Latvia*
**(rihards.murnieks@rtu.lv)*

Abstract – We analyze the construction of entanglement distribution networks based on quantum memories and numerically investigate the distribution of entanglement on a real-world fiber grid in Latvia, connecting Lithuania and Estonia. The connection is realized over a chain of processing-node quantum repeaters between two end-nodes separated by 280 km of optical fiber. Additionally, restrictions imposed by a real-world fiber grid, which result in asymmetric node placement, are accounted for when obtaining the results. We investigate two potential network architectures feasible under the fiber line's restrictions on repeater node placements and compare the achievable quantum entanglement connection fidelity using nitrogen vacancy centers in diamond quantum memories with single-click and double-click entanglement distribution protocols. To obtain our results, we use NetSquid, a discrete-event simulator for quantum networks. This enables us to include noise models and the required classical control communication. Our work serves as a first step toward establishing a blind quantum-computation infrastructure in the Baltic Sea region and highlights key challenges in realizing quantum-repeater networks.

Keywords – entanglement distribution network, long-distance quantum networking, quantum communications

Optical, electrodynamic and magnetic levitation of microspheres and microdroplets as candidates for whispering gallery mode resonators

Janis Alnis¹

¹*Institute of Atomic Physics and Spectroscopy, Faculty of Science and Technology,
University of Latvia, Riga, Latvia*

**(janis.alnis@lu.lv) Email of the corresponding author*

Abstract – Whispering gallery mode (WGM) resonators are transparent round objects that can propagate light by total internal reflection and can be very sensitive interference sensors. If a transparent microdroplet could be levitated by some means, then its shape will be perfectly round and have a simple transversal mode structure. Electrodynamic traps are used to trap ions in vacuum with applications in optical clocks and quantum computers. Here we have trapped triboelectrically charged 15 micrometer acrylic plastic PMMA micro-spheres in air (Fig.1a). In future we would like to trap a glycerol microdroplets doped with dye and demonstrate lasing. A complication is that need a pulsed dye laser for pumping of such microdroplets and achievable output power is quite small for most practical applications. Optical tweezers work by light pressure where photons transfer their momentum to the object upon refraction and scattering. We have managed to trap about 20 micrometer diameter glycerol microdroplets in air in the focus of a 150 mW green or red laser beam (Fig.1b). Droplets were doped with Rhodamine 6G dye with an idea to make a microsphere dye laser. Unfortunately, the dye immediately bleached in the green trap beam. We think that it might be possible to use infrared light for trapping that would not bleach the dye and dope with rare earth elements like Erbium, Ytterbium or Dysprosium.

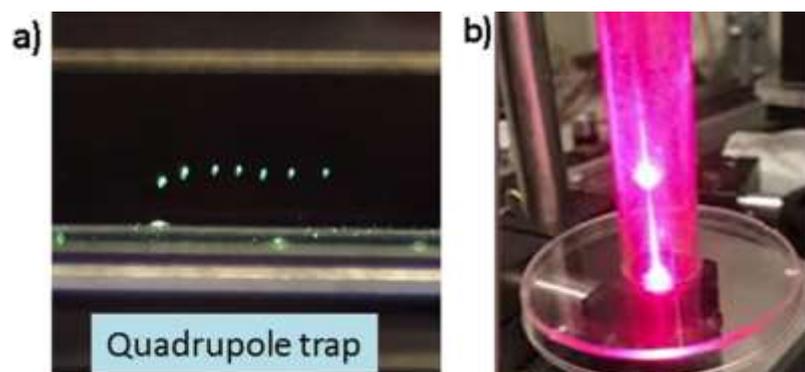


Fig. 1. a) Electrodynamic levitation of 15 micron PMMA microspheres forming a string of charged particles in air between the quadrupole electrodes supplied with 50 Hz AC 2kV. b) Optical tweezers in air trapping a single glycerol microdroplet by focussing 650nm 100 mW diode laser beam.

Acknowledgments: This research was supported by the Latvian Quantum Technologies Initiative, Project Nr. 2.3.1.1.i.0/1/22/I/CFLA/001.

Keywords – WGM whispering gallery mode resonators, optical tweezers, microdroplets, levitation, quadrupole trap

CMOS-compatible integrated single-photon sources in the visible to near-infrared spectral region

Stefano Azzini^{1*}, Matteo Sanna^{1§}, Alessio Baldazzi¹, Nicolò Broseghini^{1§§}, Gioele Piccoli², Mher Ghulynyan² and Lorenzo Pavesi¹

¹*Department of Physics, University of Trento, Trento, Italy*

²*Center for Sensors and Devices, Fondazione Bruno Kessler, Trento, Italy*

[§]*Current affiliation: Rotonium srl, Padova, Italy*

^{§§}*Current affiliation: Sony, Trento, Italy*

**stefano.azzini@unitn.it*

Abstract – CMOS-compatible integrated photonic platforms are key enablers for scalable and robust quantum technologies, also when operating at visible to near-infrared wavelengths, which are relevant for room-temperature detectors and hybrid light–matter interfaces. Here we report on the experimental realization and characterization of silicon nitride (SiN) chip-based sources of correlated photon pairs and heralded single photons emitting around 780 nm. Photon pairs are generated through spontaneous four-wave mixing in thin, low-loss SiN devices fabricated by LPCVD, and two distinct geometries are experimentally studied: centimetre-long spiral waveguides and microring resonators with high quality factors.

We observe photon-pair generation in both architectures, with rates exhibiting the expected quadratic dependence on pump power. Spiral waveguides provide direct evidence of correlated photons emission in the visible–near-infrared range, albeit with limited efficiency and a very poor signal-to-noise ratio due to a strong background of uncorrelated photons. In contrast, microring resonators benefit from resonant field enhancement, yielding a MHz-level on-chip pair generation rate with 8 mW of coupled pump power. Using the microring source, we further assess the nonclassical character of the emitted light by measuring the heralded second-order autocorrelation function, obtaining values below unity, indicating a clear antibunching behaviour.

Our results represent an important step toward a CMOS-compatible and fully integrated quantum photonic platform operating at room temperature, highlighting both the potential as well as the current limitations.

Keywords – photon pairs, single photons, silicon nitride, room temperature, CMOS

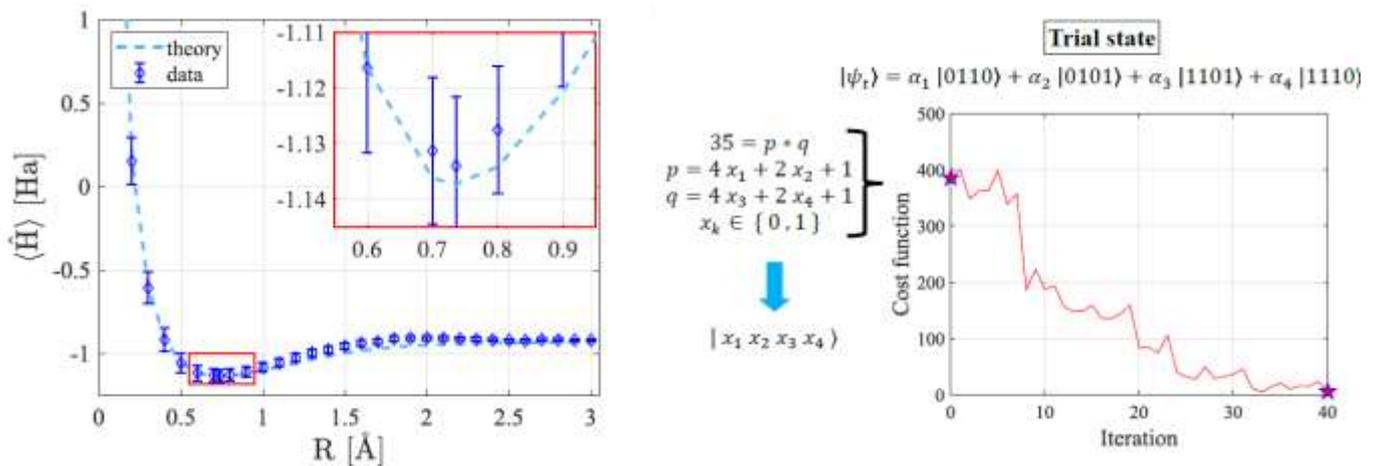
A quantum variational silicon photonic solver

Alessio Baldazzi^{*1}, Stefano Azzini¹ and Lorenzo Pavesi¹

¹Department of Physics, University of Trento, Italy
^{*}alessio.baldazzi@unitn.it

Abstract – Variational quantum algorithms (VQAs) are hybrid quantum-classical algorithms that are tailored to solve a specific task, characterized by a cost function. They involve a reconfigurable quantum system and a standard PC. The first element prepares trial states, whose measurement provides the data for the classical unit. Then, the PC computes the cost function of the problem and updates the preparation setting of the quantum unit through an optimization routine. The overall procedure is successful when the iterative exchange of data between the two components ends with the convergence of the cost function.

In the Nanoscience Laboratory, we designed and successfully validated a reconfigurable silicon photonic integrated circuit able to perform different VQAs at room temperature. The circuit is composed of robust and well-known photonic structures, combined to generate and manipulate entangled photon pairs. In particular, two entangled ququarts can be encoded in photon pairs generated with four identical spontaneous-four-wave-mixing-based integrated photon pair sources. The correlations of these photon pairs represent the resource for preparing generic trial states. A variational quantum eigensolver for the Hydrogen molecule and a variational quantum factorization for small semiprime numbers have been executed through our photonic circuit. Given its adaptability, the utilized circuit scheme has also been used to implement a novel VQA for the travelling salesman problem.



On the right, experimental and theoretical values of the Hydrogen molecules' ground state energy as a function of the atomic distance. Each point is the minimum energy for a fixed atomic distance. The red-border inset shows a zoomed version of the data around the energy minimum. On the left, we show the ansatz and our encoding in the qubit register for the factorization of 35. Then, we present the general trial state, which is a superposition of possible solutions: (3,5), (3,3), (7,3), (7,5), and the evolution of the cost function.

Our result represents the first demonstration of VQAs on a photonic quantum simulator with integrated photon pair sources, marking a significant step toward a fully integrated photonic quantum processor.

Keywords – Variational Quantum Algorithms, Silicon Photonics, Quantum Photonics, Entangled Photon Source, Four-wave mixing, Quantum chemistry, Factorization.

Quantum Sensing Inside Theranostic Metamaterial Capsules

Pavel Ginzburg¹

¹*School of Electrical Engineering, Tel Aviv University, Israel*

*pginzburg@tauex.tau.ac.il

Abstract –

Multifunctional nanoparticles that combine therapy, imaging, and actuation can serve as electromagnetically responsive theranostic carriers. We present a metamaterial capsule platform based on porous vaterite microspheres infused with gold nanoseeds, which create tunable electric and magnetic Mie resonances while preserving bio-friendly material choices. Visible-to-near-infrared absorption enables light-driven heating, supporting externally triggered release concepts and compatibility with photoacoustic and optical readout schemes.

To extend functionality beyond optothermal control, the same capsule architecture can host magnetic payloads and quantum reporters. Needle-free optothermal propulsion of vaterite nanocapsules has been demonstrated as a delivery and activation mechanism in tissue phantoms and a living-cell model, establishing its feasibility for spatially targeted deployment under optical control. For quantitative magnetic characterization at the single-capsule level, wide-field quantum-diamond microscopy has been used to map stray fields from individual vaterite microspheres loaded with magnetite nanoparticles, providing direct access to magnetic-moment variability across particles.

Building on that capability, we outline integrating nanodiamonds containing nitrogen vacancy centers into the capsule volume to enable optical readout of local magnetic signatures around the carrier. This sensing route supports in vivo monitoring scenarios, including neural activity-related field transients, and can be extended toward other biologically relevant local parameters through calibrated spin-based observables. Ongoing evaluations with clinical partners are discussed, together with pathways toward closed-loop, light-activated theranostic operation.

Keywords – Theranostics, Nanoparticles, Quantum Sensing, Biophotonics

Birefringent Spherulite Optomechanics for Dual Quantum pH and Magnetic Bio-Sensing

Tamara Amro¹, Mohammad Attrash¹, Pavel Ginzburg², Vjaceslavs Bobrovs³, Nir Bar-Gill⁴, Hani Barhum^{1*}

¹ Triangle Regional R&D Center, Kfar Qara 3007500, Israel

² School of Electrical Engineering, Tel Aviv University, Tel Aviv 69978, Israel

³ Riga Technical University, LV-1658 Riga, Latvia

⁴ Dept. of Applied Physics, Hebrew University of Jerusalem, Jerusalem 91904, Israel

A birefringent vaterite–nanodiamond hybrid enables orientation-locked optical trapping and robust quantum sensing in liquids. Stable ODMR (2–8 %), single-exponential $T_1 \approx 60 \mu\text{s}$, and threefold T_1 shortening for $\Delta\text{pH} \approx 0.3$ reveal proton-driven dielectric-gate coupling, establishing a compact, biocompatible platform for optomechanical and chemical quantum sensing in physiological media.

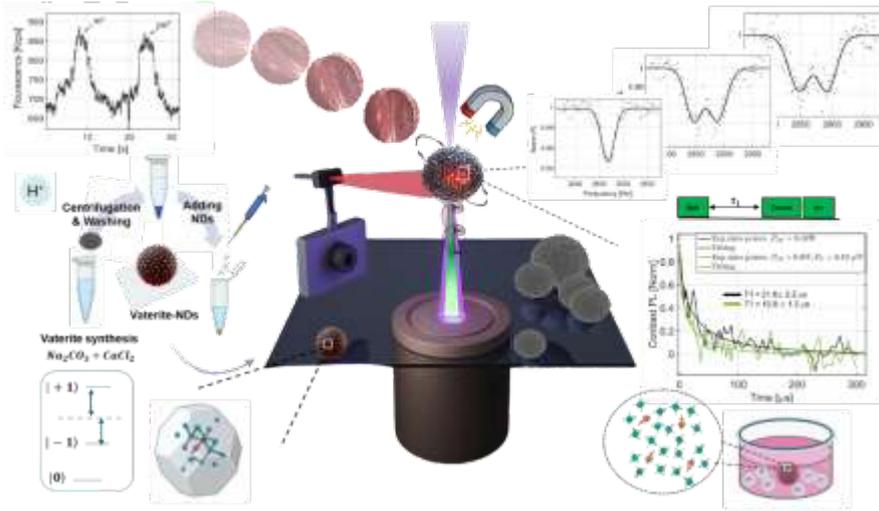


Fig. 1 Spherulite representation with meaningful optical access and quantum nanosensor in optical trapping sensing mode

Nitrogen-vacancy (NV) centers in diamond enable atomic-scale sensing but lose coherence in liquids due to random rotation and weak spin-environment coupling. We realize a birefringent vaterite-nanodiamond (ND) hybrid, where optical anisotropy locks NV orientation under 976 nm circularly polarized trapping, aligning the NV axis to the beam polarization and suppressing diffusion. The system sustains ODMR contrasts of 2 – 8% with < 0.5% spectral drift up to 0.8 W and $T_1 \approx$ negatively charged carbonate-PSS

$60 \mu\text{s}$ under continuous-wave operation. The interface ($\zeta \approx -40\text{mV}$) focuses protons and shifts the effective pK_a by 0.3 – 0.8 units, enhancing interfacial magnetic noise at the NV transition ($\omega_0 = 2\pi \times 2.87\text{GHz}$). The measured threefold T_1 shortening from $60 \mu\text{s} \rightarrow 20 \mu\text{s}$ for $\Delta\text{pH} \approx 0.3$ corresponds to $\Delta T_1/T_{10} \approx 3$ for $\Delta[\text{H}^+] \approx 2 \times 10^{-7}\text{M}$. Control experiments in D_2O and ethanol confirm that the relaxation originates from proton mobility and dielectric-gate transmission, not optical heating. The relaxation follows

$$\frac{1}{T_1} = K \left[\sum_s N_s^{\text{eff}} f_s (1 - f_s) \right] \frac{\tau_c}{1 + \omega_0^2 \tau_c^2} \left(\frac{r_0}{d} \right)^3 M(\sigma, \epsilon_r)$$

where f_s is the proton-site occupancy, $\tau_c^{-1} = D_H/d^2 + k_{\text{exch}}$ combines diffusion and exchange, and $M = [1 + (\omega_0 \epsilon_r \epsilon_0 / \sigma)^2]^{-1}$ represents the dielectric gate. In water-like media ($\sigma \approx 3\text{Sm}^{-1}$) $M \approx 0.1$ (open gate), whereas in ethanol ($\sigma \approx 10^{-4}$) $M < 10^{-8}$ (closed gate), explaining the weak T_1 response observed experimentally. Finite-difference time-domain simulations show that surface z -dipoles form directional photonic nanojets with a Purcell enhancement $F_P \approx 1.3 - 1.4$ along the optical axis, matching the 10 – 40% PL modulation measured in D_2O under polarization rotation. The $4 \mu\text{m}$ vaterite microsphere thus acts simultaneously as optical trap, micro-lens, and proton-amplifying scaffold, achieving single-exponential relaxation ($n \approx 1$) and stable operation in physiological media. This optically trapped quantum metamaterial merges optomechanical alignment, Purcell-enhanced emission, and GHz-band chemical-noise transduction-providing a mobile, biocompatible sensor for realtime pH and magnetic-field mapping in complex biological environments.

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Keywords – Include at least 5 keywords or phrases

Nanodiamond – Spin relaxation – Quantum noise – Nano spherulite - ODMR

Room-Temperature Magnetic Vortices in the van der Waals Magnet Fe_5GeTe_2 .

Elias Sfeir* (1), Carolin Angela Schrader (1), Mário Ribeiro (2), Giulio Gentile (2), Alain Marty (2), Céline Vergnaud (2), Frédéric Bonell (2), Isabelle Robert-Philip (1), Aurore Finco (1), Matthieu Jamet (2), Vincent Jacques (1)

(1) Laboratoire Charles Coulomb, Université de Montpellier, CNRS, Montpellier, France

(2) Université Grenoble Alpes, CEA, CNRS, IRIG-SPINTEC, Grenoble, France

**elias.sfeir@utt.fr*

Abstract – Recent work demonstrated ferromagnetic order at room temperature in a 12 nm-thick Fe_5GeTe_2 grown by Molecular Beam Epitaxy [1]. This result calls for further investigation on this material, in the view of future spintronic applications.

An area of exploration is the effect of patterning on its magnetic state [2], which we address here using micrometric structures of different shapes -- squares, discs, and rectangles -- lithographed in a Fe_5GeTe_2 film.

We study these microstructures with scanning NV center magnetometry, an highly effective technique for quantitative and non-perturbative imaging of magnetic textures at the nanoscale, owing to its high magnetic sensitivity of a few $\mu\text{T}/\sqrt{\text{Hz}}$ and its spatial resolution about 50 nm. We first demonstrate the stabilization at room temperature of magnetic vortices in various micrometric structures of sizes ranging from 4 to 1 μm , while smaller objects host a single ferromagnetic domain.

Second, we apply an external magnetic field with a magnitude of 6 mT and observe the vanishing of the vortices. We then extract the saturation magnetization M_s of the material from our images of the stray field generated by the resulting ferromagnetic state. We obtain a value of M_s about 200 kA/m.

Finally, we observe the restabilization of the magnetic vortices after removing the external magnetic field.

This research highlights the potential of the van der Waals magnet Fe_5GeTe_2 for applications, with the demonstration of the stabilization and manipulation magnetic vortices at room temperature [3]. It also shows the crucial role of confinement in the stabilization of complex magnetic states in 2D magnets.

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Keywords – Include at least 5 keywords or phrases

Fe_5GeTe_2 , microstructures, magnetic vortices, NV center magnetometry, high magnetic sensitivity

Microwave-Free Detection of magnetic nanostructures using zero-field cross-relaxation feature of nitrogen-vacancy centers in nanodiamond

Mona Jani ^{1*}, Reinis Lazda ¹, Maria Paz Camposano Moore ^{2,3}, Eva Grauda ¹, Alise Cirse ¹, Omkar Dhungel ^{2,3}, Anna Ermakova ⁴, Dmitry Budker ^{2,3}, Mārcis Auziņš ¹

¹Laser Center, University of Latvia, Latvia

²Helmholtz-Institut Mainz, GSI Helmholtz Zentrum für Schwerionenforschung GmbH, Germany

³Johannes Gutenberg-Universität Mainz, Germany

⁴Physics Department, Hasselt University, Belgium

*mona.jani@lu.lv

Abstract – Zero-field cross-relaxation (ZFCR) features of nitrogen-vacancy (NV) centers in diamond enable microwave-free magnetic detection and imaging, which is particularly advantageous for bio-related applications. Further, fluorescent nanodiamonds (FNDs) hosting NV centers are non-toxic and biocompatible, making them well-suited for such studies. In this work, using the ZFCR feature of NVs and a home-built optical setup, we observe a characteristic drop in photoluminescence near zero external magnetic field for FNDs. When magnetic nanostructures, such as iron oxide nanoparticles and magnetic pigments in music recording tapes, are placed in close proximity to the FND surface, pronounced variations in cross-relaxation magnetic shifts, contrast, and linewidths are observed compared to FNDs alone. These variations enable the detection and spatially resolved stray-magnetic field mapping of magnetic nanostructures without microwave excitation or external bias fields, unlike prior ODMR techniques. Providing a promising platform for quantum sensing and imaging in complex and biologically relevant environments where conventional microwave-driven techniques are disruptive.

Keywords – Nitrogen-Vacancy centers in Nanodiamond; Zero-field Cross relaxation; Microwave free; Quantum Sensing and Imaging; Magnetic nanostructures

From Materials to Devices: Graphene and 2D Materials for Photonic Platforms

Anna Baldycheva^{1*}

¹*Centre for Graphene Science, University of Exeter, United Kingdom*

**a.baldycheva@exeter.ac.uk*

Abstract – Graphene and two-dimensional (2D) materials offer a unique combination of optical, electrical, mechanical, and chemical properties that make them powerful building blocks for next-generation photonic technologies. Their atomically thin structure enables strong light–matter interaction, broadband optical response, mechanical flexibility, and compatibility with diverse substrates, providing an exceptional degree of freedom for engineering functionality directly at the material level. By tailoring parameters such as layer number, stacking configuration, interfacial chemistry, and functionalisation, these materials can be customised to deliver tunable optical absorption, enhanced conductivity, reconfigurability, and environmental sensitivity.

In this talk, I will present our recent work on transforming graphene and 2D materials from individual functional layers into scalable photonic platforms. I will discuss two complementary routes. The first is the development of multilayer and hybrid material architectures, including vertically stacked 2D heterostructures and liquid-phase-processed nanocomposites, enabling flexible, conformal, and multifunctional photonic components. The second route focuses on integration with CMOS photonics, where graphene-based coatings and functional layers are incorporated through back-end-of-line processes and through microfluidics-enabled interfaces. These approaches allow the creation of reconfigurable modulators, detectors, interconnects, and lab-on-chip photonic systems with enhanced scalability and reduced fabrication complexity.

Together, these developments illustrate a material-driven pathway from tailored 2D layers to practical photonic devices and platforms, opening new opportunities for integrated, flexible, and adaptive photonic technologies.

Keywords – Graphene, 2D Materials, Photonics, CMOS Integration, Functional Materials, Reconfigurable Photonics

ML-Enabled Mode Mismatch Mitigation in CV-QKD under DSP Constraints

Svitlana Matsenko^{*}, Amirhossein Ghazisaeidi², Konrad Banaszek^{3,4}, Darko Zibar⁵

¹*DTU Electro, Technical University of Denmark, Denmark*

²*Nokia Bell Labs, France*

³*Centre for Quantum Optical Technologies, CeNT, Poland*

⁴*Faculty of Physics, University of Warsaw, Poland*

^{*}*svitma@dtu.dk*

Abstract – Continuous-variable quantum key distribution (CV-QKD) is practically limited by mode mismatch and constrained digital signal processing (DSP) resources. We present a machine learning–based optimization framework for Gaussian-modulated CV-QKD that mitigates mode mismatch through the optimization of finite impulse response (FIR) filters under digital signal processing (DSP) hardware constraints. A reinforcement learning (RL) approach is employed to directly maximize the secure key rate (SKR), leading to a significant improvement in the achievable SKR.

Keywords – Continuous-variable quantum key distribution system (CV-QKD), machine learning (ML), algorithms, secret key rate (SKR), digital signal processing (DSP).

Continuous-variable quantum key distribution (CV-QKD) is a promising technology for enabling quantum-secure communication over optical fiber networks. However, practical implementations are strongly constrained by mode mismatch and hardware limitations of digital signal processing (DSP) resources. In particular, finite-length transmitter pulse-shaping and receiver matched filters introduce mode mismatch, resulting in intersymbol interference and excess noise that significantly degrade the secure key rate (SKR). These impairments are further exacerbated by limited digital-to-analog and analog-to-digital converter (DAC/ADC) resolution, which introduces quantization noise and compounds mode mismatch effects.

Fig. 1 shows the Simulation setup of the CV-QKD system, which includes DAC – digital-to-analog converter; ADC – analog-to-digital converter; SKR – secret key rate.

Numerical results demonstrate that the proposed reinforcement learning–based optimization effectively mitigates mode mismatch under DSP hardware constraints, leading to a significant improvement in the achievable SKR. The optimized FIR filters achieve optimal performance while satisfying practical constraints on the filter length imposed by DSP implementations. These results provide useful insights into CV-QKD performance under limited DSP resources and highlight the potential of machine learning–enabled signal processing for practical quantum-secure communications.

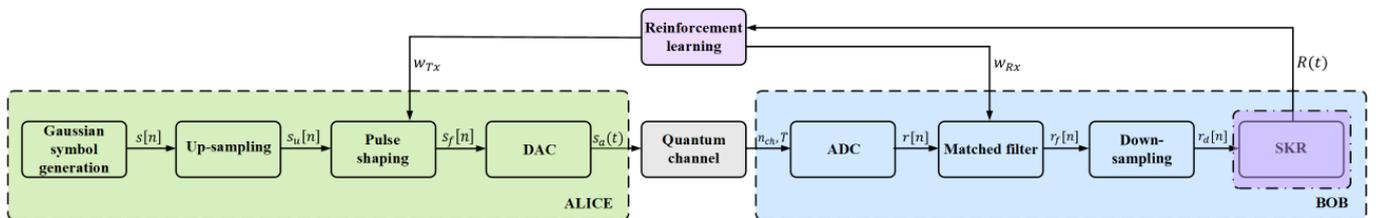


Fig. 1 Simulation setup of the CV-QKD system includes DAC – digital-to-analog converter; ADC – analog-to-digital converter; SKR – secret key rate.

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Deterministic quantum dot based photon-emitter technology

Juan Loredo ^{1,*}

¹Sparrow Quantum ApS, Nordre Fasanvej 215, 2000 Frederiksberg, Copenhagen, Denmark

**juan.loredo@sparrowquantum.com*

Abstract – The control of quantum states of light enables advancing multiple modern technologies. Semiconductor artificial atoms, such as quantum dots embedded in photonic structures, offer some of the most advances sources of quantum light. In this context, we describe Sparrow Quantum technology for producing high-performing sources of single-photons with features approaching the ideal.

Keywords – *Single-photon source, semiconductor quantum dots, quantum optics, quantum photonics*

Spin-orbit dynamics of optical vector vortices in coherently prepared atomic media with Λ and tripod configuration

 Dharma P. Permana^{1,2,3*}, Mazena Mackoite Sinkevičienė¹, Julius Ruseckas⁴, and Hamid R. Hamedi¹
¹*Institute of Theoretical Physics and Astronomy, Vilnius University, Saulėtekio 3, Vilnius LT-10257, Lithuania*
²*Laser Research Center, Vilnius University, Vilnius, LT-10223, Lithuania*
³*Département Physique, Faculté Des Sciences, Aix-Marseille Université, Marseille, France*
⁴*Baltic Institute of Advanced Technology, LT-01403 Vilnius, Lithuania*
[*dharma.permana@ff.stud.vu.lt](mailto:dharma.permana@ff.stud.vu.lt) or dhp.permana@gmail.com

Abstract – We investigate the propagation of an optical vector vortex beam weakly interacting with a coherently prepared atomic medium (phaseonium) in a three-level Λ configuration and a four-level tripod system by introducing a strong control field. The weak vector probe beam consists of paired vortex pulses carrying opposite orbital angular momentum (OAM) charges $\pm l$, with opposite spin angular momentum (SAM) associated with orthogonal circular polarizations of opposite handedness. In the linear propagation regime without the control field, we analytically show that the topology of the vortex pairs is transferred to the atomic medium and appears as a spatially structured transparency windows with a $2|l|$ -fold degeneracy, transforming the ring-shaped intensity profile into a petal-like pattern. The OAM-induced spatial modulation of the atomic coherence introduces an effective anisotropy in the medium, giving rise to spin-orbit coupling, observed as an evolution of polarization textures during propagation. The initial ground-state populations of the phaseonium controls the SAM exchange, allowing the polarization state to evolve between left-circular, linear, and right-circular polarizations [1]. When a strong control field is applied and the probe beam is resonant with the atomic transitions, the system enters the electromagnetically induced transparency (EIT) regime, suppressing both the $2|l|$ -fold degeneracy and spin-orbit coupling. A slight detuning from resonance restores spin-orbit coupling while maintaining low absorption, enabling efficient SAM exchange without intensity loss and preserving the petal-like structure.

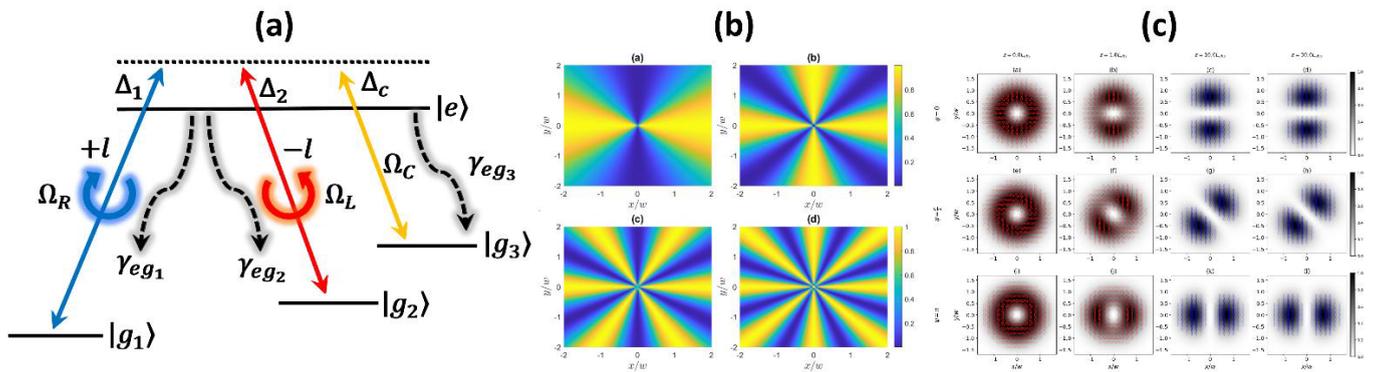


Figure 1. (a) Four-level tripod configuration. (b) The $2|l|$ -fold transparency windows, and (c) the polarization state transitions from left-circular polarization (red) to right-circular polarization (blue) in the Λ configuration without the control field [1].

Keywords – Light-matter interaction, orbital angular momentum of light, spin-orbit coupling, electromagnetically induced transparency, quantum optics

Reference:

[1] D. P. Permana, M. M. Sinkevičienė, Julius Ruseckas, Hamid R. Hamedi, "Spin-orbit coupling of optical vector vortices in coherently prepared media," arXiv:2511.17406 (2025). DOI: 10.48550/arXiv.2511.1740 (pre-print submitted to Physical Review A)

Quantum optics using colour centres in diamond

Christophe Couteau ^{1,2*}

¹Laboratory Light, nanomaterials & nanotechnologies - L2n, University of Technology of Troyes (UTT) & CNRS UMR 7076, Troyes, France.

²EUT+ Institute of Nanomaterials and Nanotechnologies EUTINN, European University of Technology, European Union, Troyes, France

³University of Oxford, Department of Physics, Clarendon Laboratory Parks Road, Oxford OX1 3PU, United Kingdom

*christophe.couteau@utt.fr

Abstract – Colour centres in diamond have emerged as outstanding solid-state platforms for quantum optics, combining room-temperature operation, long spin coherence times, and stable single-photon emission. Among them, nitrogen-vacancy and silicon-vacancy centres provide optically addressable quantum emitters that enable the generation, manipulation, and detection of non-classical states of light. Building on advances in nanodiamond engineering and photonic coupling, recent work has demonstrated highly efficient single-photon sources, controlled light–matter interactions, and coherent spin–photon interfaces. In particular, the integration of diamond colour centres with optical nanostructures allows enhanced emission rates, improved collection efficiencies, and deterministic coupling to photonic modes. These developments open new perspectives for quantum communication, quantum sensing, and fundamental tests of quantum coherence at the nanoscale. This approach establishes diamond colour centres as key building blocks for scalable quantum photonic technologies.

Keywords – Quantum optics, quantum communications, colour centres in diamond

Structural, Electronic, and Nonlinear Optical Properties of Bis(L-Proline) Cadmium Iodide Single Crystal: A Combined XRD and DFT Study

Fatima Zohra Boudjenane^{*}, Yasmine Boulediab

¹ Institute of Chemistry and Chemical Technology, Faculty of Natural Sciences and Technology, Riga Technical University

² Department of Chemistry, Faculty of Exact and Applied Sciences, University of Oran 1 Ahmed Ben Bella, 31000 Oran, Algeria

^{*}(Fatima-Zohra.Boudjenane@rtu.lv) Email of the corresponding author

Abstract – This work investigates the crystal structure and nonlinear optical (NLO) properties of the single-crystal bis(L-proline) cadmium iodide (BLPC) compound with the chemical formula $C_{10}H_{18}I_2CdN_2O_4$. This material is of particular interest due to its potential applications in advanced photonic and nonlinear optical technologies. Geometry optimization was performed using density functional theory (DFT) with the LanL2DZ and 6-31G(d,p) basis sets, showing good agreement with the experimentally determined single-crystal X-ray diffraction (XRD) data. The most stable DFT-optimized geometry was subsequently employed to compute the nonlinear optical parameters, confirming BLPC as a promising candidate for NLO applications. Further insights into the electronic structure and intermolecular interactions were obtained through Hirshfeld surface analysis, which highlights the nature of crystal packing and noncovalent interactions. Frontier molecular orbital (HOMO–LUMO) analysis, global reactivity descriptors, and molecular electrostatic potential (MEP) mapping were used to describe charge distribution, charge-transfer pathways, and overall molecular reactivity. In addition, transition density matrix (TDM) analysis was carried out to elucidate electron–hole distributions within the molecule, providing a deeper understanding of charge-transfer mechanisms responsible for the observed nonlinear optical response. These combined experimental and theoretical results demonstrate the potential of BLPC as an efficient NLO material for photonic applications.

Keywords – NLO, DFT, LanL2DZ, TDM, HOMO-LUMO

Development of host-guest polymer photonic element fabrication for integrated quantum photonics

Anete Sapne^{*}, Arturs Bundulis¹ and Alessio Baldazzi²

¹Laboratory of Organic Materials, Institute of Solid State Physics, University of Latvia, Latvia

²Laboratory of Nanoscience, Department of Physics, University of Trento, Italy

**(anete.sapne@cfi.lu.lv) Email of the corresponding author*

Abstract – The advancement of quantum communication and computing using integrated photonic devices requires to develop integrated photon sources. Both single and entangled photon source development have two main challenges – selecting materials with high nonlinear efficiency and developing the fabrication process suitable for these materials. While several material platforms for photonic applications are being developed, there is no single platform that can provide all of the necessary elements for a fully functional optical device. Heterogeneous integrated polymer photonic platform has a unique advantage, since the compatibility of polymers with other materials is not restricted by crystalline lattice and polymers can be simply integrated through wet-coating methods. Additionally, organic materials have large nonlinear coefficient values, which is crucial for lower power device fabrication, and the molecular structure can be modified to influence nonlinear response.

Here we show the fabrication process and optical properties of host-guest polymer photonic elements with novel glass forming organic materials. Z-scan method was used to study the nonlinear optical properties of organic materials in chloroform solutions. The results show that these materials have large third-order Kerr coefficient. The host-guest structures with SU-8 photoresist and the organic materials were used to fabricate spiral waveguides and frequency combs with ring resonators, with dimensions obtained from simulations. The host-guest and pure SU-8 structures were fabricated using direct laser writing optical lithography. Optical losses of these structures were characterized.

Keywords –Heterogeneous integration; quantum photonics; integrated polymer photonics; nonlinear optics; entangled photon source.

Fiber-Based Source for Polarization-Entangled Photon Pair Generation at Hybrid Network Wavelengths

 Gustas Liaugminas¹, Julijanas Želudevičius¹ and Kęstutis Regelskis¹
¹Center for Physical Sciences and Technology, Vilnius, Lithuania

 (gustas.liaugminas@fmf.lt)

Entangled photon pairs are a key resource for quantum communication, distributed quantum computing, and scalable quantum networks. Fiber-based sources are particularly attractive because they offer excellent mode matching to single-mode fibers, alignment-free operation, and seamless integration with existing telecommunication infrastructure. In this work, we present a fiber-based source for polarization-entangled photon pair generation based on spontaneous four-wave mixing (SFWM) in polarization-maintaining photonic crystal fiber (PM-PCF) in a Sagnac loop configuration. The Sagnac loop is pumped using 200 ps pulses at 1038 nm, generating nondegenerate photon pairs with signal and idler wavelengths at 831 nm and 1381 nm, respectively. This wavelength combination is particularly attractive for hybrid quantum networks, as it combines low-loss transmission in standard telecom fiber with compatibility with high-efficiency silicon single-photon detectors and quantum memory platforms operating in the near-infrared. Polarization entanglement is produced by coherently superposing photon-pair generation processes from counter-propagating, orthogonally polarized pump pulses in the Sagnac interferometer. The experimental setup employs a fiber-based pump laser, pulse picking and amplification stages, and mutually twisted PM-PCF arms to ensure stable polarization control and phase matching. Signal and idler photons are separated using spectral filtering and detected with avalanche photodiodes, with polarization analysis performed using waveplates and polarizing beam splitters. The demonstrated source provides a compact, stable, and network-compatible platform for polarization-entangled photon generation, potentially suited for future hybrid quantum networking applications.

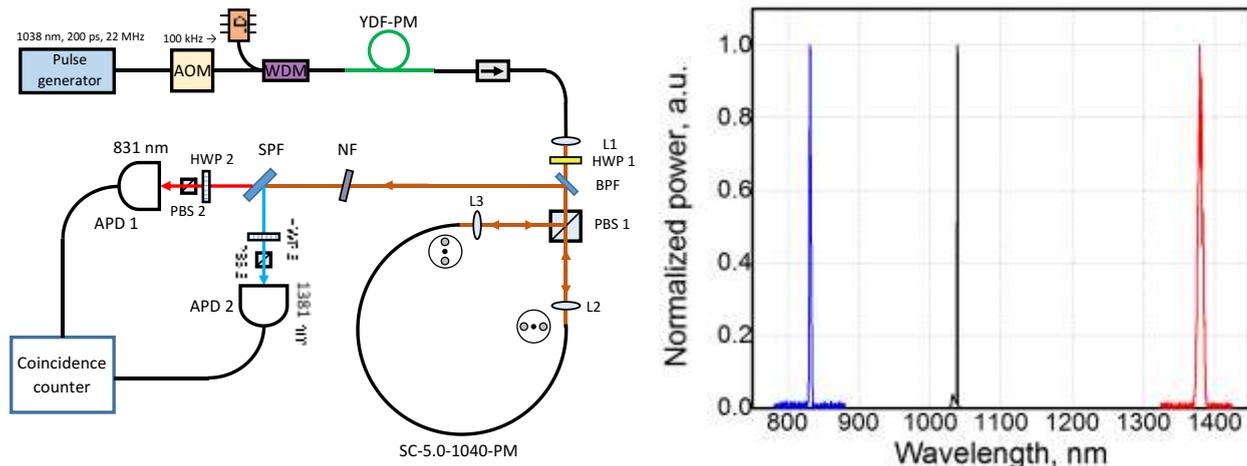


Fig. 1. Polarization-entangled photon pair generation setup (left). Spectra of pump, signal and idler waves generated in the PM-PCF (right).

Acknowledgement: This project has received funding from the Research Council of Lithuania (LMTLT), agreement No. [P-MIP-24-668].

Keywords – Fiber lasers, Non-linear optics, Quantum key distribution, Quantum communication, Entangled pair generation

Synthesis and Characterization of Organic NLO Chromophores for Integrated Photonics

Kirills Dmitrijevs^{*1}, Kaspars Traskovskis¹, Egons Oskars Judrups², Anete Sapne², Artūrs Bundulis², Mārtiņš Rutkis²

¹Institute of Chemistry and Chemical technology, Riga Technical University, Latvia

²Institute of Solid State Physics, University of Latvia, Latvia

*kirills.dmitrijevs@rtu.lv

Abstract – Emerging data-driven technologies are driving increased interest in the seamless integration of electronics and photonics. A key element of such integration is electro-optical switches (EOS). EOS based on the electro-optical effect offer clear advantages over existing switching technologies, while organic materials outperform their inorganic counterparts in terms of efficiency. For comparison, the commercially available D- π -A-type chromophore **JRD1** exhibits electro-optical (EO) coefficients exceeding 300 pm/V in bulk form and approaching 200 pm/V in EOS devices, significantly surpassing those of inorganic alternatives such as lithium niobate, which are typically around 20 pm/V. Aforementioned organic materials can be used to generate correlated or entangled photon pairs for applications in quantum photonics.

Herein, we report the synthesis of three novel chromophores (**1–3**), designed based on the **BAH13** and **JRD1** architectures. Optimization of the final synthetic stage was carried out by screening various reaction conditions. To demonstrate the potential applications of the obtained dyes, trench waveguides with widths of 2–40 μm were fabricated in quartz and filled with dyes **1–3**. The nonlinear optical (NLO) properties of the synthesized chromophores were compared with those of **JRD1**, providing a face-to-face comparison of the **BAH13** and **JRD1** architectures.

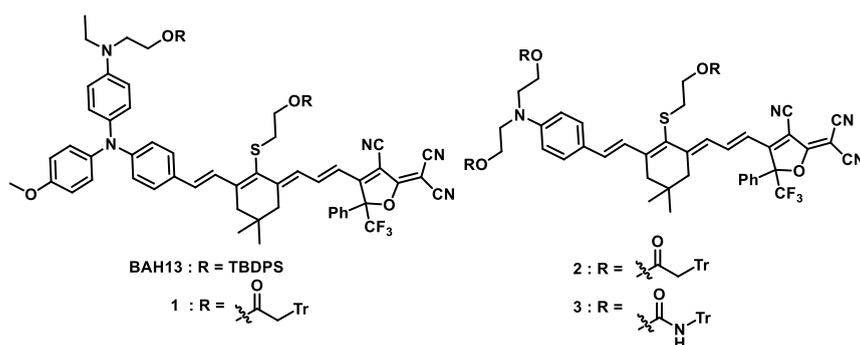


Figure 1. Obtained materials.

Acknowledgements - This work was supported by the Horizon 2020 programme through grant 101070332 (PHORMIC).

Keywords – electro-optical switches, electro-optical modulators, second-order nonlinear optics, inkjet printing, organic chromophore.

Long-term stability of integrated SU-8 polymer ring resonators

Lāse Mīlgrāve^{*1} and Jānis Alnis¹

¹*Institute of Atomic Physics and Spectroscopy, Faculty of Science and Technology, University of Latvia, Latvia*

^{*}*lase.milgrave@lu.lv*

Abstract – Microresonators are widely applicable in many areas, such as optical sensing, signal processing, and integrated photonics. Whispering gallery mode (WGM) resonators can be microscopic while still exhibiting high quality (Q) factors and strong light-matter interaction. While materials like silicon, silicon nitride, and lithium niobate are a more traditional choice for integrated photonics structures, polymers offer several advantages – low-cost fabrication, tailored materials, and fabrication can be done using photolithography. In this work, we investigate the long-term stability of integrated SU-8 ring resonators. SU-8 is a negative photoresist, and it is suitable for integrated photonics due to its high refractive index $n = 1.58$ and its high optical transparency. We experimentally tested and measured the Q factors of ring resonators over a period of several months. The resonators were kept in the ambient conditions of the laboratory, which experiences some air humidity (30–60 % RH) and temperature (18–21 °C) changes. For further investigation of the Q factor degradation, the samples were exposed to UV light and high air humidity. We observed a slow degradation of the Q factor over time. Prolonged UV exposure caused noticeable degradation of the samples, which we observed as weakened transmission and the absence of resonant dips in some resonators. Meanwhile, exposure to high air humidity momentarily introduced noises and lower transmission intensity, but full signal strength and Q factor were regained after drying. Further research is necessary to fully understand and improve the long-term stability of polymer resonators in order to enable their integration into photonic chips.

Keywords – integrated photonics; polymer photonics; SU-8; ring resonator; whispering gallery mode resonator,

The analysis of possible quantum technology applications onboard modern ships

Gundis Lauža¹, Miroslavs Mališko²

¹*Riga Technical University, Latvian Maritime academy, Latvia*

²*Riga Technical University, Latvian Maritime academy, Latvia*

**Miroslavs.Malisko@rtu.lv*

Abstract – This paper presents a review of possible quantum technology applications onboard vessels. One of the main technology applications is in ship navigation systems and equipment which can be affected by environmental factors, interference and failures, operational flexibility, precision and construction complexity, as well, as security and regulatory compliance. The paper analyzes principles of quantum navigation systems and compares them with conventional navigational aids. Technology can have also an important impact on maritime autonomous navigation systems.

This paper covers also other areas of use of quantum technology in maritime industry. Apart from navigational systems quantum technology can be used also in maritime communications, computer systems and energy management systems. Quantum computing could be used in prediction of weather and sea states, traffic and collision risks, machinery failures, fuel consumption, vessel behavior.

Environmental protection and emission control is another area where quantum technologies are considered for use.

The paper also provides key considerations to ensure secure and effective implementation of quantum technology onboard modern ships, as well as the challenges which can be faced in future system integration in maritime industry. Finally, the suggestions and proposals are given on which equipment onboard existing vessels to focus on when considering quantum technology integration as well as seafarer training requirements.

Quantum navigation systems, maritime communications, quantum computing, autonomous shipping, LIDAR.

Polymeric Pillar Microcavities for Enhanced Single-Photon Emission from Organic Molecules

Margarita Anna Zommere*, Maja Colautti², Elena Fanella², Rocco Duquennoy², Sven Burger³, Fridtjof Betz³, Costanza Toninelli²

¹ *Institute of Solid-State Physics, University of Latvia, Latvia*

² *LENS - European Laboratory for Non-Linear Spectroscopy, Italy*

³ *Zuse Institute Berlin, Germany*

**margarita-anna.zommere@cfi.lu.lv*

Single-photon emitters are essential for photonic quantum communication, where information is carried one photon at a time. Among the many possible systems, organic molecules particularly polycyclic aromatic hydrocarbons (PAHs) remain highly attractive because they can produce bright, narrow and nearly transform-limited emission when cooled to cryogenic temperatures. Dibenzoterrylene (DBT) embedded in anthracene crystals is a well-studied example (DOI:10.1038/s41563-021-00987-4). The drawback is that a single molecule radiates in all directions, which makes it difficult to collect single-photons efficiently or guide them into an optical circuit.

This work takes a step toward solving this limitation by incorporating DBT-doped anthracene crystals into polymer microcavities that confine and redirect the emitted light. The cavities are written directly on the crystal matrix surface using two-photon polymerization, a fabrication method that can print three-dimensional structures with sub-micron precision exactly where the molecule-rich regions are located (DOI: 10.1002/qute.202400107). The design of each cavity is optimized through numerical simulations to resonate at the DBT zero-phonon line near 785 nm, increasing the emission rate and steering photons into well-defined optical modes through the Purcell effect.

This direct-laser-writing strategy avoids difficult bonding or etching steps and is compatible with integrating arrays of organic molecule - based quantum emitters. The long-term goal is to push organic molecules from lab demonstrators toward scalable, compact and integrated single-photon sources on chip-scale platforms for quantum photonic technologies.

This method provides a practical route to enhancing the brightness of organic single-photon emitters and integrating them into compact, coherent quantum photonic chips.

DBT - Dibenzoterrylene

Anthracene

Purcell-Enhanced Emission

Two-Photon Polymerization

Organic Single-Photon Source

Tantalum pentoxide microring resonators

Kristians Draguns¹, Janis Alnis¹

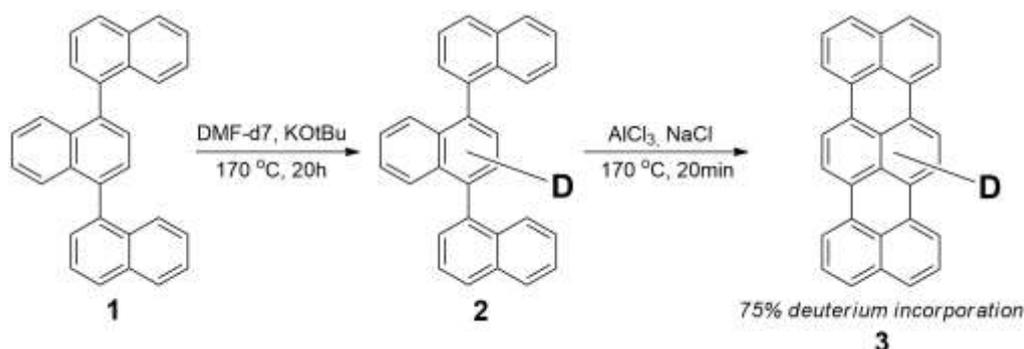
Abstract – Tantalum pentoxide is a dielectric material used in integrated photonics with a high refractive index $n_{1550} = 2.06$ and high nonlinear refractive index $n_2 = 6.2 \cdot 10^{-19} \text{ m}^2/\text{W}$. The fabrication is CMOS compatible using electron beam lithography. The achieved Q factors of the microring structures exceed $Q = 1M$, and experiments show nonlinear effects such as unsymmetrical resonances. In this work we compare simulation data with experimental data for the dispersion of the resonator, which is important for generating Kerr frequency combs.

Deuteration Strategies for Single-Photon Emitter Molecules

 Armands Rudušs ^{*1} and Kaspars Traskovskis ¹
¹Faculty of Materials Science and Applied Chemistry, Riga Technical University, Latvia

*(armands.ruduss@rtu.lv)

Terrylene and dibenzoterrylene (DBT) are highly valued as single-photon emitters in quantum photonics. Both molecules are used to generate single photons on demand. It has been shown that deuteration – replacement of the hydrogen atoms (¹H) with deuterium (²H or D) – significantly improves DBT as a single photon source by suppressing non-radiative energy loss.¹ In particular, deuteration of DBT decreases the rate of internal conversion and leads to an increase in fluorescence lifetime and quantum yield.



Scheme 1. Deuteration method of terrylene.

In this study a series of experiments were conducted to find the optimal conditions for the highest deuterium incorporation in terrylene or DBT molecules. In the case of terrylene direct deuterium exchange was unattainable and a two-step synthesis was used instead (see Scheme 1). First, the starting material **1** was deuterated using commercially available DMF-d_7 as the deuterium source and potassium *tert*-butoxide as a basic catalyst.² The deuterated terrylene **3** was obtained from intermediate **2** via Scholl coupling reaction in a $\text{AlCl}_3/\text{NaCl}$ melt. A deuterium incorporation of 75% was determined using NMR spectroscopy. A method introduced by Mishra et al. was utilized for deuteration of DBT.¹ In this case a similar Scholl coupling reaction was performed in a chlorobenzene- d_5 as a solvent and deuterium source with AlCl_3 as acidic catalyst. However, the formation of many unidentified by-products greatly obstructs the isolation of the deuterated DBT from the reaction mixture.

References:

- [1] K. Mishra et al. *Chem. Sci.*, **2025**, 16, 90-97.
 [2] A. K. Greene et al. *J. Org. Chem.*, **2013**, 78, 2139-2143.

Keywords – terrylene, dibenzoterrylene, deuteration, single-photon emitters.

Quantum imaging with undetected infrared light generated by spontaneous parametric down-conversion in nonlinear crystals

Reinis Lazda*, Tīna Jansone, Mārcis Kalējs, Šarlote Simšone, Florian Gahbauer and Marcis Auzinsh

Laser Centre, University of Latvia, Jelgavas street 3, LV-1004, Riga, Latvia

*reinis.lazda@lu.lv

Quantum imaging with undetected photons is a manifestation of quantum interference and entanglement, enabling the visualization of objects using photons that never directly interact with the detector, see FIG. 1. In this work, we report on the development of a compact experimental setup aimed at demonstrating this effect in a laboratory environment.

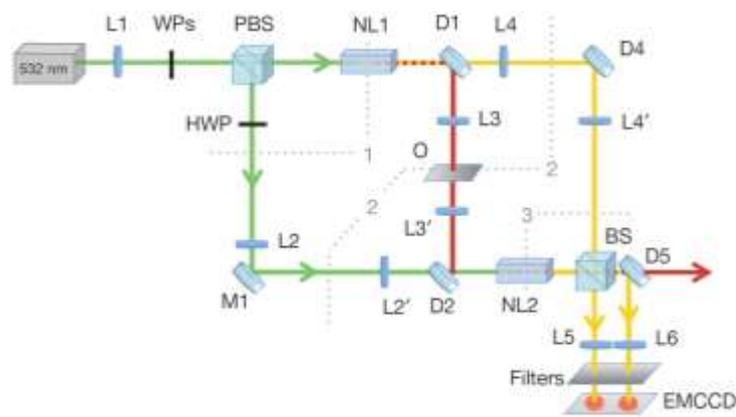


FIG. 1: Experimental setup. A 532 nm laser (green) illuminates crystals NL1 and NL2. The dichroic mirror D1 separates down-converted 810 nm (yellow) and 1550 nm (red) photons. The 1550 nm photons are transmitted through the object O and sent through NL2 by dichroic mirror D2. A 50:50 beam splitter (BS) combines the 810-nm beams [1].

The key idea of the method is based on the generation of pairs of entangled photons via spontaneous parametric down-conversion in nonlinear crystals. This allows imaging at a wavelength different from the illumination wavelength, enabling visualization of objects that are opaque or invisible at the detection wavelength, including imaging through scattering media such as fog or smoke (for potential defence applications).

Acknowledgements:

We acknowledge the support from LLC “MikroTik” and the Foundation of the University of Latvia, project: "Quantum imaging with undetected photons".

References:

[1] Lemos, G., Borish, V., Cole, G. et al. Quantum imaging with undetected photons. *Nature* **512**, 409–412 (2014), <https://doi.org/10.1038/nature13586>

Keywords – quantum imaging, undetected photons, quantum entanglement, spontaneous parametric down-conversion, nonlinear crystals

Direct Synthesis and Characterization of Graphene/h-BN Layers and Heterostructures for Quantum Applications

Šarūnas Meškiniš^{*}, Andrius Vasiliauskas, Asta Guobienė, Šarūnas Jankauskas, Mindaugas Andrulėvičius, Rimantas Gudaitis

¹*Institute of Materials Science, Kaunas University of Technology, Lithuania*

^{*}*(sarunas.meskinis@ktu.lt)*

Abstract – 2D nanomaterials, graphene and hexagonal boron nitride (h-BN), have received considerable interest as potential new materials for quantum technologies. Notably, graphene-based magnetic quantum sensors and qubits for quantum computers are investigated. h-BN is intensively studied as a host for single-photon emitters, positioning it as a potential alternative to diamond. Fabrication of graphene/h-BN heterojunctions and Moiré superlattices offers even more opportunities for quantum technologies. However, both graphene and h-BN are typically fabricated by exfoliation or by transferring the 2D nanolayers grown by CVD onto catalytic metal foils onto target substrates. standard semiconductor fabrication processes. In addition, exfoliation is not suitable for large area deposition. In contrast, the transfer process is lengthy and prone to contamination by various adsorbates. Therefore, direct synthesis of these nanomaterials on semiconducting and dielectric substrates would be highly beneficial.

In the present research, h-BN films were deposited by reactive high-power impulse magnetron sputtering (HIPIMS) on the Si(100). Graphene layers were synthesized directly on silicon, SiO₂, and h-BN substrates. The structure of the 2D nanomaterials was evaluated using Raman scattering spectroscopy (excitation wavelength 532 nm). The morphology of the samples was studied by atomic force microscopy (AFM). The composition of the h-BN films was estimated using X-ray photoelectron spectroscopy (XPS). The electrical and optoelectronic properties of graphene and graphene/h-BN heterostructure-based devices were investigated. Strong photoluminescence was observed in some h-BN films, attributed to carbon-related defect states. The graphene and h-BN structures obtained, along with their electronic and optoelectronic properties, provide a promising material platform for integration into quantum photonic devices, single-photon detectors, and 2D-material-based quantum sensors.

Keywords – graphene, h-BN, direct synthesis, HIPIMS, microwave PECVD

High-order coherences for magnetic field sensing beyond low-field limits

Arturs Mozers*, D. Jermačāne, J. Birznieks, L. Mikelsons, F. Gahbauer
and M. Auzinsh

University of Latvia FST Laser Centre, Latvia

**(arturs.mozers@lu.lv) Email of the corresponding author*

Abstract – This document presents the formatting instructions for the Proceedings of the International conference on quantum photonics development in Baltic region. This document can serve as the base template for a Microsoft Word based typesetting system. The abstract should state briefly the purpose of the research, the approach used, the principal results and major conclusions. The abstract of 200-250 words is required and it should not exceed one page including figures.

While atomic magnetometers are highly effective at measuring zero to ultra-low fields, their accuracy in the microtesla range—such as Earth-scale fields—is often compromised by the nonlinear Zeeman (NLZ) effect. Rather than relying on standard correction techniques for these NLZ-related errors, this study utilizes high-order coherences i.e. $m = \pm 2$ sublevels of the ^{87}Rb $F_g = 2$ ground state for magnetic field sensing beyond low-field limits.

We intend to increase the accuracy of ^{87}Rb atomic magnetometers by completely eliminating the NLZ heading error via the creation of hexadecapole moments ($\Delta m = 4$ coherences) with a precise sequence of modulation pulses and to improve sensitivity by using fluorescence instead of optical rotation.

Keywords – Atomic magnetometry, Zeeman effect, magnetic field, quantum sensors, coherences

NV-Based Spin–Photon Optical Communication

Ziad Abi Akar^{*}, Surena Fatemi, Roy Konnoth Ancel, Elias Sfeir, Christophe Couteau^{*}

¹*Light, Nanomaterials And Nanotechnology, University of technology of Troyes, France*

^{*}*Christophe.couteau@utt.fr*

Abstract – Solid-state quantum emitters are promising building blocks for future quantum networks. Nitrogen-vacancy (NV) centers in diamond combine microwave spin control with optical excitation and spin-dependent photoluminescence, making them attractive for spin–photon protocols. We present an optical communication scheme where information is encoded through controlled spin dynamics and mapped onto an optical intensity signal measurable by photon-counting detection. We describe the experimental implementation, including microwave-driven spin manipulation and time-tagged photon detection, and we analyze the attainable modulation contrast and link-level signal-to-noise performance. Importantly, the presented protocol is compatible with extensions toward quantum communication architectures, where the same control and readout primitives can support quantum state preparation and spin–photon interfacing. This work positions NV centers as a practical platform for nanoscale optical transmitters and provides a pathway from classical modulation experiments to quantum network functionalities.

Keywords – Include at least 5 keywords or phrases

- *Nitrogen-vacancy (NV) centers*
- *Spin–photon interface*
- *Microwave spin control (ODMR / Rabi dynamics)*
- *Spin-dependent photoluminescence*
- *Time-tagged photon counting (single-photon detection)*



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