3rd International Conference for Young Quantum Information Scientists

$\langle \Psi | \mathrm{QIS} \rangle_{2017}$

BOOK OF ABSTRACTS

Wilhelm und Else Heraeus Stiftung

MAX PLANCK INSTITUTE for the science of light

FRIEDRICH-ALEXANDER UNIVERSITÄT ERLANGEN-NÜRNBERG

YQIS 2017

Origin of YQIS

Initiated by Alain Aspect (Institut d’Optique Graduate School, Palaiseau, France) and Sébastien Tanzilli (Université Nice Sophia Antipolis, France), the first edition of YQIS was held at the Institut d’Optique Graduate School in Palaiseau, France, and was made possible thanks to a fraction of the 2013 Balzan Prize awarded to Alain Aspect for his pioneering work in the field of quantum information and communication. Promoting pedagogical actions towards young research fellows is one of the major concerns of the International Balzan Prize Foundation.

About YQIS

The International Conference for Young Quantum Information Scientists (YQIS) is organized by young researchers for young researchers (doctoral students and post-doctoral fellows) and covers theoretical and experimental topics ranging from the very foundations of quantum information to applied quantum systems. The first edition of YQIS was held at the Institute d'Optique, Palaiseau (France), in 2015. There, 109 participating young researchers from all over the world made the conference a great success by contributing 22 talks and 86 scientific posters. The second edition of YQIS took place at the Institute of Photonic Sciences, Barcelona (Spain), in 2016. The number of participants grew to 160 (27 contributed talks, over 140 posters), showing increasing demand for the YQIS. Following this successful start, the third edition of the YQIS will be held in Erlangen, Germany. The researchers will present their research in one of the following categories:

- Quantum foundations
- Quantum correlations and networks
- Condensed matter and many-body systems
- Quantum thermodynamics and open systems
- Quantum metrology
- Quantum communications and cryptography
- Quantum simulation and computation
- Technologies for quantum information processing

Scientific background

Quantum information science is an interdisciplinary research area of physics, mathematics, and computer sciences, and was originally emerged from quantum physics. The development of quantum physics begins with Planck's quantum hypotheses explaining the optical spectrum of black-body radiation (1900). Subsequently, the quantum hypotheses was used by Einstein to understand the photoelectric effect (1905). Afterwards, the Bohr-Sommerfeld model of the atom (from 1913), and de Broglie's matter-waves hypotheses (1924) led to the mathematical formulations of quantum physics by Heisenberg, Born, Jordan and Schrödinger (1926).

Fundamental research in quantum physics triggered many enabling technologies of the 20th century which led to our contemporary digital society. One of the most prominent examples among them is the invention of the laser which can nowadays be found in a variety of electronic products.

Still, fundamental research in quantum physics and quantum information continues to be an innovation driver. Recently, the control over individual quantum objects such as single atoms and photons was achieved, allowing a close inspection and exploitation of quantum physical principles like superposition, entanglement, and many-body phenomena. These capabilities go far beyond current technological limitations and might significantly increase the usability of novel quantum technologies, e.g. quantum computing, quantum metrology, and quantum cryptography. It is therefore understandable that the importance of quantum information in science, industry, and society is supported by a variety of national and international initiatives that aim to advance research and technological development in quantum information.

Aim of the third edition

Talks in scientific conferences often communicate solely fundamental concepts of experiments and theoretical models. Technical details that are mandatory for an accurate experiment or for an exact theoretical calculation are, in contrast, not often addressed. This may be surprising since technical details are often of utmost importance for a successful research project. Addressing this topic in a scientific conference might therefore increase the quality of research experiments and efficiency of many projects.

To address this problem, the International Conference for Young Quantum Information Scientists (YQIS) organizes a conference especially for young scientist which are predominantly solving technical details during their PhD-studies. The conference aims to provide a stage for scientific exchange in Quantum Information Science and an exchange of scientific experiences during poster-sessions or scientific talks. As a consequence, scientific talks should mainly be held by students. Such kind of conference format is unusual but triggers a large gain in practical know-how. The gain in practical know-how might even be amplified by involving selected experienced senior scientists during their invited talks, during the discussions after each student-talk, and during the poster-sessions.

In addition, the International Conference for Young Quantum Information Scientists aims to point out the important role of Quantum Information Science for industrial applications in the near future. Apart from university-based senior researchers, it is therefore also intended to invite industrial-based researchers. Their insights might give an overview which technological improvements are potentially relevant and which market might be interested in Quantum Information based technology. Furthermore, their discussions with students might trigger innovative ideas.

Advisory Committee

Alain Aspect is Augustin Fresnel Professor at Institut d'Optique, Professor at Ecole Polytechnique, and CNRS Distinguished Scientist (Directeur de recherche CNRS) emeritus at Laboratoire Charles Fabry. He is a member of the French Academy of Sciences, the French Academy of Technologies, and of the Royal Society (UK). In 2005, he was awarded the Gold Medal of the Centre national de la recherche scientifique, where he is currently Research Director. The 2010 Wolf Prize in physics was awarded to Alain Aspect, Anton Zeilinger, and John Clauser. In 2013, he was awarded the Danish Niels Bohr International Gold Medal, and was also awarded the Balzan Prize for Quantum Information Processing and Communication. The International Balzan Prize Foundation awarded Alain Aspect in 2013 "for his pioneering experiments which led to a striking confirmation of Quantum Mechanics as opposed to local hidden-variable theories. His work has opened the way to the experimental control of entangled quantum states, the essential element of Quantum Information Processing."

Gerd Leuchs is one of the director of the Max-Planck-Institute for the Science of Light (MPL) in Erlangen, Germany, an Adjunct Professor at the University of Ottawa in Canada and an honorary Professor of the St. Petersburg State University, Russia. He is the Fellow of the European Optical Society, of the Optical Society of America and of the Institute of Physics, UK. He is also a member of the German Academy of Science Leopoldina and the Russian Academy of Sciences. He received his PhD in 1978 and Habilitation degree in 1982 from Ludwig-Maximilians University in Munich. Also in 1979, he received a Feodor-Lynen Stipend from the Alexander-von-Humboldt Foundation and, from 1983 to 1985, a Heisenberg-Fellowship of the Deutsche Forschungsgemeinschaft. In 1980/81, he was a Visiting Fellow at the Joint Institute for Laboratory Astrophysics at Boulder, Colorado. At this time, his scientific work concentrated on laser spectroscopy and multi-photon processes. From 1985 to 1989, he was leading the gravitational-wave-detection group at the Max-Planck-Institut for Quantenoptik in Garching. From 1990 to 1994, he was the Technical Director of Nanomach AG, Switzerland and, in 1994, he was appointed the Chair of Optics at Erlangen University. From 2003 to 2008, he was the director of the Max-Planck Research Group Optics on Information and Photonics. After two successful scientific evaluations when the Max Planck Society decided to establish the new Max Planck Institute for the Science of Light at Erlangen, then in January 2009, he became one of its directors. In 2005 he won the Quantum Electronics Prize of the European Physical Society. In 2012 he received the cross of merit of the Federal republic of Germany. In 2013 he won the ERC Advanced Grant and recently in 2016 he also received the honorary doctoral degree from the Danish Technical University (DTU) in Lyngby, Denmark.

Sébastien Tanzilli is Research Director at CNRS, with the Laboratoire de Physique de la Matière Condensée (LPMC) at the University Nice Sophia Antipolis (UNS). At LPMC, he leads the team “Quantum Information with Light & Matter” (QILM), which aims at exploiting integrated photonics and cold atomic ensembles as enabling technologies for quantum communication and information science. He was awarded the 2014 UNS outstanding research prize, one of the 2013 Grants from the Simone & Cino Del Duca (Institut de France) Research Foundation, the 2010 IXCORE Research Foundation prize, the 2009 CNRS Bronze Medal, and the 2008 Fabry - de Gramont Prize from the French Optical Society (SFO).

Local Organizing Committee

Lucas Alber	Max Planck Institute for the Science of Light, Erlangen, Germany
Ömer Bayraktar	Max Planck Institute for the Science of Light, Erlangen, Germany
Sourav Chatterjee	Max Planck Institute for the Science of Light, Erlangen, Germany
Golnoush Shafiee	Max Planck Institute for the Science of Light, Erlangen, Germany

Scientific Committee

Christian Mueller	Max Planck Institute for the Science of Light, Erlangen, Germany
Carlos Navarrete-Benlloch	Max Planck Institute for the Science of Light, Erlangen, Germany
Kaushik Seshadreesan	Max Planck Institute for the Science of Light, Erlangen, Germany
Bharath Srivathsan	Max Planck Institute for the Science of Light, Erlangen, Germany

ABSTRACTS OF CONTRIBUTIONS

YQIS 2017 1

Origin of YQIS 1
About YQIS 1
Scientific background 2
Aim of the third edition 2
Advisory Committee 3
Local Organizing Committee 4
Scientific Committee 4

ABSTRACTS 03.10.2017 10

High-Helicity Vortex Conversion in a Rubidium Vapor 10
Finite Quantum State Verification, Validation, and Imaging via Phase Space Methods 10
Temporal shaping of single photons enabled by entanglement 11
Strong photon-atom coupling with 4Pi microscopy 11
Optimal verification of entangled states with local measurements 12
Realistic parameter regimes for a single sequential quantum repeater 12
Finite-resource teleportation stretching for continuous-variable systems 13
Hybrid Photonic Loss Resilient Entanglement Swapping 13
Towards Accessible Metropolitan Quantum Secure Communication 14
The Security of the Quantum MAC 14
Quantum-Limited Measurements of Optical Signals from a Geostationary Satellite 15
Device Independent Conference Key Agreement 15
Experimental observation of the interplay between quantum coherence and quantum correlations 16
Witnessing irreducible dimension 16
Approximate Majorization 17
Certifying global randomness from partially entangled two-qubit states 17
All entangled states can demonstrate non-classical teleportation 18
Extending Wheeler's delayed-choice experiment to Space 18
Experimental certification of millions of genuinely entangled atoms in a solid 19
Entanglement detection on an NMR quantum-information processor using random local measurements 20
Efficient experimental design of high-fidelity three-qubit quantum gates via genetic programming . 20
Objectivity in non-Markovian spin-boson model 21
Complementarity of genuine multipartite Bell nonlocality 21
Steady-state generation of maximal entanglement in any dimension via incoherent contact to thermal baths 22
Routing entanglement in a quantum network 22
Measuring higher-dimensional entanglement 23
Superradiance of Classical Fields via Projective Measurements 23
Controlling adsorbate distributions on a silica-coated gold surface measured by Rydberg spectroscopy 24
Complementary Relations Between Quantum Steering Criteria 24
Non-Markovian time evolution of an accelerated qubit 25
Optimising practical entanglement distillation 25
A quantum particle in a cavity with alternating boundary conditions 26

ON-CHIP GENERATION OF FREQUENCY-ENTANGLED QUDITS 26
RANDOMNESS, INDISTINGUISHABILITY AND THE ENVIRONMENT AS A QUANTUM TURING MACHINE 27
QUANTUM DOT IMPLEMENTATION OF LARGE ERROR CORRECTION CODES 27
SCALABILITY OF QUANTUM MEMORY 28
COVERT QUANTUM INTERNET 28
QUANTUM STREAMING ALGORITHMS FOR ONLINE MINIMIZATION PROBLEMS AND QUANTUM ONLINE ALGORITHMS WITH ADVICE 29
IMPROVING THE DISSIPATIVE PRODUCTION OF A MAXIMALLY ENTANGLED STATE VIA OPTIMAL CONTROL 29
NONCLASSICALITY IN OPTICAL SYSTEMS 30
COMMUNICATION COMPLEXITY FOR MIXED PROTOCOLS 30
QUANTUM BATTERIES 31
TRADING QUBIT RESOURCES FOR QUANTUM SIMULATION OF ELECTRONIC SYTEMS 31
HIGH MAGNETIC FIELD GRADIENT TIPS FOR SINGLE SPIN RESONANCE IMAGING 32
PHOTON REFLECTION BY A QUANTUM MIRROR: A WAVE-FUNCTION APPROACH 32
QUANTUM SIMULATORS FOR OPEN QUANTUM SYSTEMS USING QUANTUM ZENO DYNAMICS 33
MUTUAL UNCERTAINTY, CONDITIONAL UNCERTAINTY AND STRONG SUB-ADDITIVITY 33
MULTIPLEXED ENTANGLEMENT GENERATION OVER QUANTUM NETWORKS USING MULTI-QUBIT NODES 34
SEMICLASSICAL LASER COOLING NEAR THE FOCAL POINT OF A PARABOLIC MIRROR 34
ROBUST SELF-TESTING OF (ALMOST) ALL PURE TWO-QUBIT STATES 35
ENTANGLEMENT AND (IN)DISTINGUISHABILITY 35
SURVIVAL OF TIME-EVOLVED QUANTUM CORRELATIONS DEPENDING ON WHETHER QUENCHING IS ACROSS A CRITICAL POINT IN AN XY SPIN CHAIN 36
MANY-BOX LOCALITY 36
GENERALIZED NON-MARKOVIAN STOCHASTIC SCHRÖDINGER EQUATION WITH APPLICATION TO ENTANGLEMENT DETECTION 37
INTERFEROMETER ALIGNMENT METHOD BASED ON THE WEAK VALUE CONCEPT 37

ABSTRACTS 04.10.2017 38

REALIZATION OF SHOR'S ALGORITHM AT ROOM TEMPERATURE 38
TOWARDS QUANTUM SIMULATION WITH CIRCULAR RYDBERG ATOMS 38
QUANTUM MECHANICS AND THE EFFICIENCY OF SIMULATING CLASSICAL COMPLEX SYSTEMS 39
FLOW AMBIGUITY: A PATH TOWARDS CLASSICALLY DRIVEN BLIND QUANTUM COMPUTATION 39
FRACTAL PROPERTIES OF MAGIC STATE DISTILLATION 40
ON THE IMPLAUSIBILITY OF CLASSICAL CLIENT BLIND QUANTUM COMPUTING 40
REMOTE POLARIZATION-ENTANGLEMENT GENERATION BY LOCAL DEPHASING AND FREQUENCY UP-CONVERSION 41
ENTANGLEMENT SCALING AT A FIRST ORDER PHASE TRANSITION 41
CONVEX OPTIMIZATION OVER CLASSES OF MULTIPARTICLE ENTANGLEMENT 42
ENTANGLEMENT AND QUANTUM COMBINATORIAL DESIGNS 42
EFFICIENT DEVICE-INDEPENDENT ENTANGLEMENT DETECTION FOR MULTIPARTITE SYSTEMS 43
CERTIFICATION OF QUANTUM NETWORK FUNCTIONALITY BASED ON MULTI-ROUND TELEPORTATION 43
INTERFERENCE OF SINGLE PHOTONS ON A SYSTEM OF COUPLED WAVEGUIDES 44
SIMULATING MARKOV TRANSITION PROBABILITIES IN A QUANTUM ENVIRONMENT 44
OPTIMIZING QUANTUM WALK SEARCH ON A REDUCED UNIFORM COMPLETE MULTI-PARTITE GRAPH 45
MULTIPARTITE ENTANGLEMENT TRANSFORMATIONS WITH LOCAL OPERATIONS AND FINITE ROUNDS OF CLASSICAL COMMUNICATION 45
BELL INEQUALITIES IN CONTINUOUS VARIABLE SYSTEMS FOR GENERAL 4-MODE GAUSSIAN STATES 46

QUANTUM SENSOR NETWORKS WITH NV CENTERS 46
ENTANGLEMENT IN QUANTUM SPIN NETWORKS WITH DEFECTS 47
TWO-PHOTON INTERFERENCE OF VAPOR-DELAYED SINGLE QUANTUM-DOT PHOTONS 47
COMMERCIALIZING CONTINUOUS-VARIABLE QUANTUM KEY DISTRIBUTION 48
ESTIMATION OF CHSH INEQUALITY FOR UNKNOWN QUANTUM STATE VIA C-SPSA 48
NEW ENTROPIC FUNCTIONS FOR QUBIT AND GAUSSIAN STATES 49
PRIVATE KEY AGAINST SIDE CHANNEL ATTACKS 49
MULTIQUBIT STATE TOMOGRAPHY WITH FINITE DATA 50
GENERALIZED PROBABILISTIC DESCRIPTION OF NONINTERACTING IDENTICAL PARTICLES 50
SIMULATING BOSON SAMPLING IN FREE SPACE 51
SLOCC HIERARCHY FOR GENERIC STATES IN 2 X M X N LEVEL SYSTEMS 51
WIDE FIELD IMAGING OF ATOMIC SPINS USING NITROGEN-VACANCY CENTERS IN DIAMOND 52
GAMES AND MONOGAMY IN THE RELATIVISTICALLY CAUSAL CORRELATIONS 52
QUANTUM DISCORD BETWEEN TWO DISTANT BOSE-EINSTEIN CONDENSATES WITH BELL-LIKE DETECTION 53
QUANTUM ALGORITHM FOR PERFECT MATCHING PROBLEM 53
ROLE OF CROSS-TALK IN MULTIMODE CONTINUOUS-VARIABLE QUANTUM COMMUNICATION 54
GENERALISED CLUSTER STATES OF MECHANICAL OSCILLATORS FOR UNIVERSAL QUANTUM COMPUTATION 54
SECURITY ANALYSIS OF THERMAL AND CONTINUOUS-VARIABLE MEASUREMENT-DEVICE-INDEPENDENT QUANTUM KEY DISTRIBUTION INCORPORATING FINITE SIZE EFFECTS 55
TRANSIENT RESPONSE OF BISTABLE SYSTEMS 55
TAMING FINITE STATISTICS FOR DEVICE-INDEPENDENT QUANTUM INFORMATION 56
ROBUST AND EFFICIENT CONTROL OF SPINS IN A COMPLEX (BIOLOGICAL) ENVIRONMENT 56
TRIPLED FREQUENCY PHOTON GENERATION IN THE FOCUS OF A DEEP PARABOLIC MIRROR IN ARGON GAS 57
SELECTION OF MULTIPARTITE SPIN STATES IN A NUCLEAR BATH 57
NANOSCALE THERMOMETRY AND MAGNETOMETRY FOR A NEW GENERATION OF HARD DISK RECORDING HEADS 58
NEGATIVELY CHARGED STATE ON PHOSPHORUS ATOM IN THE SILICON QUANTUM COMPUTER ARCHITECTURE 58
THE PROBLEM OF QUANTUM INFORMATION'S TRANSMISSION THROUGH A FIELD 59
SIMULATION OF NON-PAULI CHANNELS 59
QUANTUM CORRELATIONS IN AN OPTOMECHANICAL CAVITY WITH A PERIODIC MODULATION 60
OPTICAL TRAPPING OF NANO-PARTICLES WITH A DEEP PARABOLIC MIRROR 60
IMPROVED QUANTUM ADVANTAGE WITH SHALLOW CIRCUITS VIA NON-LOCAL GAMES 61
ARTIFICIAL SUBSYSTEMS IN MULTILEVEL SINGLE-PART SYSTEMS AND NEW INFORMAION-ENTROPIC INEQUALITIES FOR CLEBSCH-GORDAN COEFFICIENTS 61
REDUCTION OF MANY-BODY TERMS FOR QUANTUM COMPUTATIONS WITH FERMIONS 62

ABSTRACTS 06.10.2017 63

PERFECT SAMPLING FOR QUANTUM GIBBS STATES 63
ENERGETIC INSTABILITY OF PASSIVE STATES IN THERMODYNAMICS 63
PHASE TRANSITION IN CHAOTIC DYNAMICS OF PURIFICATION PROTOCOL 64
BEATING THE LIMITS IN QUBIT RESET WITH INITIAL CORRELATIONS 64
AUTONOMOUS QUANTUM CLOCKS: HOW THERMODYNAMICS LIMITS OUR ABILITY TO MEASURE TIME 65
STATE TRANSFER IN A ONE-DIMENSIONAL STRONGLY-INTERACTING GAS 65
PRECISION ARRANGEMENT OF PHOSPHORUS ATOMS ON SI(100) THROUGH CHLORINE MASK 66
ULTIMATE LIMITS FOR QUANTUM MAGNETOMETRY VIA TIME-CONTINUOUS MEASUREMENTS 66
HIGH RESOLUTION SENSING OF HIGH-FREQUENCY FIELDS WITH CONTINUOUS DYNAMICAL DECOUPLING 67

SIMULTANEOUS ESTIMATION OF CONJUGATE PARAMETERS: REACHING THE CRAMÉR-RAO BOUND WITH COHERENT STATES **68**

LIST OF AUTHORS **69**

Abstracts 03.10.2017

High-Helicity Vortex Conversion in a Rubidium Vapor

Aurélien Chopinaud, Marion Jacquey, Bruno Viaris de Lesegno and Laurence Pruvost

Speaker: Aurélien Chopinaud *03.10.2017, 10:30* *Talk*

An optical vortex is a light beam with a helically-shaped wavefront and a doughnut-like intensity. Such a beam carries an orbital angular momentum (OAM), which is quantized with a signed integer l related to the helix period. This quantum variable is also called the third momentum of light. We realized a vortex-conversion from red to blue using the 5S-5D two-photon transition in a rubidium vapor cell, monitored with a Gaussian beam at 780 nm plus a vortex beam at 776 nm with helicity l . The 5D level emission creates an infrared photon at 5.23 μm and a blue one at 420 nm. With a parallel co-propagating beam configuration, we demonstrate a high-helicity transfer, typically for l ranging -30 to +30, on the output blue beam which respects the OAM conservation. We further show that the output beam size respects the envelope of the input beams and that the conversion efficiency decreases with l, in respect with the input beams overlap. In addition we show the blue wave is a nearly pure Laguerre-Gaussian mode. That guaranties a high fidelity of the device viewed as an OAM transmitter and opens possibilities in the field of quantum variable manipulation for quantum communication.

Finite Quantum State Verification, Validation, and Imaging via Phase Space Methods

Russell P. Rundle, Patrick W. Mills, Todd Tilma, John H. Samson and Mark J. Everiit

Speaker: Russell P. Rundle *03.10.2017, 10:45* *Talk*

Since its introduction in the 1930s by Wigner, and its generalisations by Moyal and Weyl, the ability to associate an operator on Hilbert space by a quasi-probability distribution function on phase space has found extensive use in the physics of continuous variable systems. Lacking, however, is finite system applications; to date, such functions have taken a back seat to state vector, path integration, and Heisenberg representations. In recent work we have addressed this lack of application by generating a Wigner distribution function for any spin-j system or Dicke state in displaced parity form. Using this work, we have shown how varied quantum systems can be easily represented in phase space as well as visualise certain quantum properties, such as entanglement, within these systems. In particular, we have applied our formalism to directly measure phase space coordinates of multiple qubit states, including a five-qubit GHZ state, on IBM's Quantum Experience. Applications to ions and photonics qubits have also been done.

Temporal shaping of single photons enabled by entanglement

Valentin Averchenko, Denis Sych, Gerhard Schunk, Ulrich Vogl, Christoph Marquardt and Gerd Leuchs

Speaker: Valentin Averchenko 03.10.2017, 11:00 Talk

We present a method to produce pure single photons with an arbitrary designed temporal shape in a heralded way. As an indispensable resource, the method uses pairs of time-energy entangled photons. One photon of a pair undergoes temporal amplitude-phase modulation according to the desired shape. Subsequent frequency-resolved detection of the modulated photon heralds its entangled counterpart in a pure quantum state. The temporal shape of the heralded photon is indirectly affected by the modulation in the heralding arm. We derive conditions for which the shape of the heralded photon is given by the modulation function. The method can be implemented with various sources of time-energy entangled photons. In particular, using entangled photons from parametric down-conversion the method provides a simple mean to generate pure shaped photons with an unprecedented broad range of temporal durations - from tenths of femtoseconds to microseconds. This shaping of single photons will push forward the implementation of scalable multidimensional quantum information protocols, efficient photon-matter coupling and quantum control at the level of single quanta.

Strong photon-atom coupling with 4Pi microscopy

Yue-Sum Chin, Matthias Steiner and Christian Kurtsiefer

Speaker: Yue-Sum Chin 03.10.2017, 11:15 Talk

Strongly interacting photons constitute a novel platform to study many-body physics and enable building blocks for quantum technologies. Photon-photon interaction being negligible in free space requires a medium to facilitate interactions. A single atom can absorb only one photon at a time and is therefore, in principle, well suited to couple simultaneously impinging photons. However, interactions between atoms and photons in the nonlinear regime at the single-photon level have been demonstrated only in the context of cavity quantum electrodynamics and Rydberg quantum optics. Here we follow a conceptually simpler approach by tightly focusing the light field onto a single atom. Our implementation uses a 4Pi microscopy configuration: A single atom is placed between two lenses in a confocal arrangement. The incident beam is split, and the atom is coherently excited by two counter propagating parts of the field simultaneously. We observe 36% extinction of the incident field, and a modified photon statistics of the transmitted field – indicating nonlinear atom-photon interaction. Our results suggest, with 4Pi arrangement, free space implementation of atom-light interaction is strong enough to enter the regime of quantum nonlinear optics.

Reference: Y.-S. Chin, M. Steiner, C. Kurtsiefer, arXiv:1705.10173 (2017)

Optimal verification of entangled states with local measurements

Sam Pallister, Ashley Montanaro and Noah Linden

Speaker: Sam Pallister *03.10.2017, 11:30* *Talk*

Consider the task of verifying that a given quantum device, designed to produce a particular entangled state, does indeed produce that state. One natural approach would be to characterise the output state by quantum state tomography; or alternatively to perform some kind of Bell test, tailored to the state of interest. We show here that neither approach is optimal amongst local verification strategies for two qubit states. We find the optimal strategy in this case and show that quadratically fewer total measurements are needed to verify to within a given fidelity than in quantum state tomography, Bell test, or fidelity estimation protocols. We also show that this quadratic advantage extends to any stabilizer state. The framework presented here is an indication that, in practice, devices for producing quantum states may be easier to verify than to characterise tomographically.

Realistic parameter regimes for a single sequential quantum repeater

Filip Rozpedek, Kenneth Goodenough, Jérémy Ribeiro, Norbert Kalb, Valentina Caprara Vivoli, Andreas Reiserer, Ronald Hanson, Stephanie Wehner and David Elkouss

Speaker: Filip Rozpedek *03.10.2017, 11:45* *Talk*

Quantum key distribution allows for the generation of a secret key between distant parties connected by a quantum channel such as optical fibre or free space. Unfortunately, the rate of generation of a secret key by direct transmission is fundamentally limited by the distance. This limit can be overcome by the implementation of so-called quantum repeaters. Here, we assess the performance of a specific but very natural setup called a single sequential repeater for quantum key distribution. We offer a fine-grained assessment of the repeater by introducing a series of benchmarks. The benchmarks, which should be surpassed to claim a working repeater, are based on finite-energy considerations, thermal noise and the losses in the setup. In order to boost the performance of the studied repeaters we introduce two methods. The first one corresponds to the concept of a cut-off, which reduces the effect of decoherence during storage of a quantum state by introducing a maximum storage time. Secondly, we supplement the standard classical post-processing with an advantage distillation procedure. Using these methods, we find realistic parameters for which it is possible to achieve rates greater than each of the benchmarks, guiding the way towards implementing quantum repeaters.

arXiv:1705.00043

Finite-resource teleportation stretching for continuous-variable systems

Riccardo Laurenza, Samuel Braunstein and Stefano Pirandola

Speaker: Riccardo Laurenza *03.10.2017, 13:00* *Talk*

We show how adaptive protocols of quantum and private communication through bosonic Gaussian channels can be simplified into much easier block versions that involve resource states with finite energy. This is achieved by combining the adaptive-to-block reduction technique devised in [Pirandola et al., arXiv:1510.08863], based on teleportation stretching and relative entropy of entanglement, with the simulation of Gaussian channels introduced by [Liuzzo-Scorpo et.,arXiv:1705.03017]. In this way, we derive weak converse upper bounds for the secret-key capacity of phase-insensitive Gaussian channel, which closely approximate the optimal limit for infinite energy. Our results apply to both point-to-point and repeater-assisted private communications.

Hybrid Photonic Loss Resilient Entanglement Swapping

Ryan Parker, Jaewoo Joo, Mohsen Razavi and Timothy Spiller

Speaker: Ryan Parker *03.10.2017, 13:15* *Talk*

We propose a scheme of loss resilient entanglement swapping between two distant parties in lossy optical fibre. In this scheme, Alice and Bob each begin with a pair of entangled non-classical states; these "hybrid states" of light are entangled discrete variable (Fock state) and continuous variable (coherent state) pairs. The continuous variable halves of each of these pairs are sent through lossy optical fibre to a middle location, where these states are then mixed (using a 50:50 beam-splitter) and measured. The detection scheme we use is to measure one of these modes via vacuum detection, and to measure the other mode using homodyne detection. In this work we show that a maximally entangled Bell state can theoretically be produced following this scheme with high fidelity and entanglement, even when allowing for a small amount of loss. It can be shown that there is an optimal amplitude value of the coherent state when allowing for such loss. We also investigate the realistic circumstance when the loss is not balanced in the propagating modes. We demonstrate that a small amount of loss mismatch does not destroy the overall entanglement, thus demonstrating the physical practicality of this protocol.

(Ref: arXiv:1706.08492v1 [quant-ph])

Towards Accessible Metropolitan Quantum Secure Communication

Henry Semenenko, Philip Sibson, Jorge Barreto and Chris Erven

Speaker: Henry Semenenko *03.10.2017, 13:30* *Talk*

As quantum key distribution (QKD) begins to move from laboratories into real-world use cases, some practical aspects need to be addressed before it can be widely adopted. Not least of which is the size and cost of the devices. The semiconductor industry, over the last 50 years, has provided a scalable platform for integrated electronics. Using the same fabrication processes, it is possible to create quantum photonic microchips to entirely replace the optical components needed for QKD. Using both indium phosphide and silicon devices, we can design and fabricate integrated devices to perform QKD with highly competitive speeds and error rates. At the same time, they offer dramatically reduced power requirements, size and costs while offering increased phase stability and inherent scalability. Other recent developments in the field include new protocols to remove the security assumptions about the physical devices used. One such protocol is measurement-device independent QKD (MDI-QKD) which removes all detector side-channels. Combining integrated devices with MDI-QKD, we are working towards developing a practical architecture for metropolitan QKD. Here, we provide a recap of QKD and discuss the current state of integrated QKD devices and their potential applications in metropolitan networks.

The Security of the Quantum MAC

Mansur Ziatdinov

Speaker: Mansur Ziatdinov *03.10.2017, 13:45* *Talk*

Quantum MAC allows two parties with a shared secret key to authenticate messages. The main advantage over classical MAC is that security of quantum MAC is guaranteed by laws of physics. Formally [3], quantum MAC is a function that accepts a key and a (classical) input and outputs a (quantum) tag. Tags are different for different messages with the same key. To be different here means that inner product of states is small (states are near-orthogonal). The probability that given zero or more text-MAC pairs an arbitrary attacker would compute text-MAC pair for some new input is negligible. We propose a quantum MAC based on the extractor against quantum storage [1]. This MAC is secure against an attacker that has the limited number of text-MAC pairs. We also propose a protocol that is based on this quantum MAC and we assess its security using the recently introduced notion of quantum information cost [2] and the notion of Holevo entropy.

[1] Ta-Shma, A. Short Seed Extractors Against Quantum Storage. Proc. ACM STOC 401‑408 (2009). [2] Touchette, D. Quantum Information Complexity. Proc. ACM STOC 317‑326 (2015). [3] Ziatdinov, M. From graphs to keyed quantum hash functions. Lobachevskii J. Math. 37, 705‑712 (2016).

Quantum-Limited Measurements of Optical Signals from a Geostationary Satellite

Kevin Günthner, Imran Khan, Dominique Elser, Birgit Stiller, Ömer Bayraktar, Christian Müller, Karen Saucke, Daniel Tröndle, Frank Heine, Stefan Seel, Peter Greulich, Herwig Zech, Björn Gütlich, Sabine Philipp-May, Christoph Marquardt and Gerd Leuchs

Speaker: Kevin Günthner 03.10.2017, 14:00 Talk

Quantum key distribution protocols have already been implemented in metropolitan networks all around the world. A promising method to provide the still missing long-haul link between such networks is optical satellite communication. To this end, existing Laser Communication Terminals (LCTs) can be adapted to be suitable for quantum communication. An important step towards this objective is to precisely characterize the quantum noise behaviour of the system including the channel. We have performed quantum-limited measurements of optical signals from the Alphasat TDP1 LCT in geostationary Earth orbit. We show that quantum coherence is preserved after propagation of the quantum states over 38600 km. An upper bound for excess noise that the states could have acquired after propagation is estimated [1].

Acknowledgements: The Laser Communication Terminal (LCT) and the Transportable Adaptive Optical Ground Station (T-AOGS) are supported by the German Aerospace Center (DLR) with funds from the Federal Ministry for Economic Affairs and Energy according to a decision of the German Federal Parliament. References: [1] K. Günthner, I. Khan et al., "Quantum-limited measurements of optical signals from a geostationary satellite," Optica 4, 611 – 616 (2017).

Device Independent Conference Key Agreement

Jérémy Ribeiro, Glaucia Murta and Stephanie Wehner

Speaker: Jérémy Ribeiro 03.10.2017, 14:15 Talk

Conference Key Agreement is an extension of Quantum Key Distribution to the N-partite scenario. We present a Device Independent Conference Key Agreement (DICKA) protocol, then we prove its security into two steps. We first use the recently developed Entropy Accumulation Theorem (by Dupuis et. al.) to split the overall min-entropy of Alice's string produced during the protocol, into a sum of the Von Neumann entropy produced in each round of the protocol (i.e. the sum of the entropy of each bit of the key). Then we develop a new method to bound the entropy produced in one round by a function of the violation of the N-partite Mermin-Ardehali-Belinskii-Klyshko (MABK) inequalities that generalizes the bounds found for the bipartite case. As far as we know this work is the first to provide a Device Independent security proof for Conference Key Agreement. We also show that DICKA can have some advantages over Device Independance QKD in certain regime of noise.

Experimental observation of the interplay between quantum coherence and quantum correlations

Gerard Jiménez Machado, Lluc Sendra Molins, Luis José Salazar Serrano, Adam Vallés Marí and Juan Pérez Torres

Speaker: Gerard Jiménez Machado 03.10.2017, 14:45 Talk

The complementarity principle is a tenet of our current understanding of quantum theory. In plain words it says that the sharpness of an interference pattern can be regarded as a measure of how wavelike the light is, and the amount of information we have obtained about the photons trajectories can be regarded as a measure of how particle-like it is. Several theoretical papers have dealt with this subject and derived a quantitative relationship for the case of an interferometer. The most relevant experiment measures the interference of Rubidium atom trajectories in a double-slit configuration, and the path witness is the quantum internal state of the atoms, that change differently depending on the path taken by the atoms. Here we demonstrate experimentally in an fully photonic interferometric system the relationship between the sharpness of interference (a measure of coherence, $G^{(1)}$), and the amount of trajectory information (a measure of degree of correlation, $G^{(2)}$). We show in this way in an experiment the relevant and fascinating interplay between quantum coherence and quantum correlations.

Witnessing irreducible dimension

Wan Cong, Yu Cai, Jean-Daniel Bancal and Valerio Scarani

Speaker: Yu Cai 03.10.2017, 15:00 Talk

The Hilbert space dimension of a quantum system is the most basic quantifier of its information content. Lower bounds on the dimension can be certified in a device-independent way, based only on observed statistics. We highlight that some such ``dimension witnesses'' capture only the presence of systems of some dimension, which in a sense is trivial, not the capacity of performing information processing on them, which is the point of experimental efforts to control high-dimensional systems. In order to capture this aspect, we introduce the notion of irreducible dimension of a quantum behaviour. This dimension can be certified, and we provide a witness for irreducible dimension four. Based on arXiv:1611.01258

Approximate Majorization

Michał Horodecki, Jonathan Oppenheim and Carlo Sparaciari

Speaker: Carlo Sparaciari   *03.10.2017, 15:15*   *Talk*

Although an input distribution may not majorize a target distribution, it may majorize a distribution which is close to the target. Here we introduce a notion of approximate majorization. For any distribution, and given a distance δ, we find the approximate distributions which majorize (are majorized by) all other distributions within the distance δ. We call these the steepest and flattest approximation. This enables one to compute how close one can get to a given target distribution under a process governed by majorization. We show that the flattest and steepest approximations preserve ordering under majorization. Furthermore, we give a notion of majorization distance. This has applications ranging from thermodynamics, entanglement theory, and economics.

Certifying global randomness from partially entangled two-qubit states

Erik Woodhead, Alexia Salavrakos, Boris Bourdoncle and Antonio Acin

Speaker: Alexia Salavrakos   *03.10.2017, 15:30*   *Talk*

The violation of Bell inequalities allows the certification of quantum properties in a device-independent way [1]. This means that random numbers [2] or the security of a secret key [3] can be guaranteed, without any assumptions on the internal functioning of the devices used in the protocol. Given the task of certifying random numbers, one can see entanglement as a resource, in the sense one can study the amount of random bits that can be extracted from various entangled quantum states. The relation between entanglement and randomness was studied in [4] and turned out to be more complex than expected. For the maximally entangled state, it is known that maximal randomness of 2 bits can be certified [5]. In our work, we develop a family of Bell inequalities to certify maximal randomness from partially entangled states of two qubits.

[1] - N. Brunner et al., Rev. Mod. Phys. 86, 419 (2014).

[2] - S. Pironio et al., Nature 464, 1021 (2010).

[3] - A. Acin et al., Phys. Rev. Lett 98, 230501 (2007).

[4] - A. Acin, et al., Phys. Rev. Lett. 108, 100402 (2012).

[5] - C. Dhara, et al., Phys. Rev. A 88, 052116 (2013).

All entangled states can demonstrate non-classical teleportation

Daniel Cavalcanti, Paul Skrzypczyk and Ivan Supic

Speaker: Ivan Supic *03.10.2017, 15:45* *Talk*

Quantum teleportation, the process by which Alice can transfer an unknown quantum state to Bob by using pre-shared entanglement and classical communication, is one of the cornerstones of quantum information. The standard benchmark for certifying quantum teleportation consists in surpassing the maximum average fidelity

between the teleported and the target states that can be achieved classically. According to this figure of merit, not all entangled states are useful for teleportation. Here we propose a new benchmark that uses the full information available in a teleportation experiment and proves that all entangled states can implement a quantum channel which can not be reproduced classically. We introduce the idea of non-classical teleportation witness to certify if a teleportation experiment is genuinely quantum and discuss how to quantify this phenomenon. Our work provides new techniques for studying teleportation that can be immediately applied to certify the quality of quantum technologies.

Extending Wheeler's delayed-choice experiment to Space

Costantino Agnesi, Francesco Vedovato, Matteo Schiavon, Daniele Dequal, Luca Calderaro, Marco Tomasin, Davide Marangon, Andrea Stanco, Vincenza Luceri, Giuseppe Bianco, Giuseppe Vallone, Paolo Villoresi

Speaker: Costantino Agnesi *03.10.2017, 16:00* *Talk*

Gedankenexperiment have been conceived to inspect the counterintuitive principles of quantum mechanics, for example, the wave-particle duality. Wheeler proposed his delayed-choice thought experiment to test the validity of the dual description of photons and to highlight the naive and contradictory interpretation given by classical physics: by changing the configuration of a two-path interferometer after the photon has entered the setup, one can either investigate the particle-like nature of the photon or its wave-like behavior. Motivated by the need of testing quantum mechanics in new scenarios, we implemented the delayed-choice experiment along a satellite-ground interferometer which extends for thousands of kilometers in Space allowing us to probe the laws of nature at this unprecedented scale.

We exploit temporal and polarization degrees of freedom of photons reflected by a fast moving satellite equipped with retro-reflecting mirrors.

Our results extend the validity of the quantum complementarity to the scale of Low Earth Orbits, paving the way for novel applications of quantum information processing in Space links involving multiple photon degrees of freedom. Furthermore, our experiment is a workbench for the development of new quantum technologies and techniques that enable the ability of propagating and controlling quantum phenomena over increasingly larger distances.

Experimental certification of millions of genuinely entangled atoms in a solid

Peter C. Strassmann, Florian Fröwis, Alexey Tiranov, Corentin Gut, Jonathan Lavoie, Nicolas Brunner, Félix Bussières, Mikael Afzelius and Nicolas Gisin

Speaker: Peter C. Strassmann *03.10.2017, 16:15* *Talk*

One of the big questions about quantum theory since its early days is asking whether entanglement as one of the fundamental quantum phenomena persists also in macroscopic systems. Nowadays the measurement of large-scale entanglement is still a hard problem. To witness entanglement we use the concept of entanglement depth defined by the system's minimal number of mutually entangled atoms. The entanglement witness used in this work is based on the coherent superposition of a single excitation shared by many atoms. Previous measurements lead to entanglement of up to 2900 particles. Our experiment witnesses genuine multipartite entanglement between 16 millions of atoms in a solid-state quantum memory even in the presence of loss and noise. The experiment consists of two steps: 1. Entanglement appears in a quantum memory realized by a Nd:YSO crystal during the storage of the single photon excitation. 2. The read-out measurements are based on the photon counts and the second-order auto-correlation function concluding on the system's entanglement depth for given system size. The resulting raw data lead directly to an entanglement depth of half a million. Inferring the photon probabilities for perfect detectors, the entanglement depth is as high as 16 millions.

Entanglement detection on an NMR quantum-information processor using random local measurements

Amandeep Singh

Speaker: Amandeep Singh *03.10.2017, 16:45* *Poster*

Random local measurements have recently been proposed to construct entanglement witnesses and thereby detect the presence of bipartite entanglement. We experimentally demonstrate the efficacy of one such scheme on a two-qubit NMR quantum-information processor. We show that a set of three random local measurements suffices to detect the entanglement of a general two-qubit state. We experimentally generate states with different amounts of entanglement and show that the scheme is able to clearly witness entanglement. We perform complete quantum state tomography for each state and compute state fidelity to validate our results. Further, we extend previous results and perform a simulation using random local measurements to optimally detect bipartite entanglement in a hybrid system of $2\otimes3$ dimensionality.

Efficient experimental design of high-fidelity three-qubit quantum gates via genetic programming

Amit Devra, Prithviraj Prabhu, Harpreet Singh, Arvind Arvind and Kavita Dorai

Speaker: Amit Devra *03.10.2017, 16:45* *Poster*

We have designed efficient quantum circuits for the three-qubit Toffoli (controlled-controlled NOT) and the Fredkin (controlled-SWAP) gate, optimized via genetic programming methods. The gates thus obtained were experimentally implemented on a three-qubit NMR quantum information processor, with a high fidelity. Toffoli and Fredkin gates in conjunction with the single-qubit Hadamard gates form a universal gate set for quantum computing and are an essential component of several quantum algorithms. Genetic algorithms are stochastic search algorithms based on the logic of natural selection and biological genetics and have been widely used for quantum information processing applications. The numerically optimized rf pulse profiles of the three-qubit quantum gates achieve >99% fidelity. The optimization was performed under the constraint that the experimentally implemented pulses are of short duration and can be implemented with high fidelity. Therefore the gate implementations do not suffer from the drawbacks of rf offset errors or debilitating effects of decoherence during gate action. We demonstrate the advantage of our pulse sequences by comparing our results with existing experimental schemes.

Objectivity in non-Markovian spin-boson model

Aniello Lampo, Jan Tuziemski, Maciej Lewenstein and Jarosław Korbicz

Speaker: Jan Tuziemski *03.10.2017, 16:45* *Poster*

Objectivity constitutes one of the main features of the macroscopic classical world. An important aspect of the quantum-to-classical transition issue is to explain how such a property arises from the microscopic quantum world. Recently, within the framework of open quantum systems, such a mechanism has been proposed in terms of the, so-called, Spectrum Broadcast Structures. These are multipartite quantum states of the system of interest and a part of its environment, assumed to be under an observation. This approach requires a departure from the standard open quantum systems methods, as the environment cannot be completely neglected. Here we study the emergence of such a state-structures in one of the canonical models of the condensed matter theory: Spin-boson model. We pay much attention to the behavior of the model in the non-Markovian regime, in order to provide a testbed to analyze how the non-Markovian nature of the evolution affects the creation of a spectrum broadcast structure.

Complementarity of genuine multipartite Bell nonlocality

Anubhav Chaturvedi, Sasha Sami and Indranil Chakrabarty

Speaker: Anubhav Chaturvedi *03.10.2017, 16:45* *Poster*

We introduce a new feature of no-signaling (Bell) non-local theories, namely, when a system of multiple parties manifests genuine non-local correlation, then there cannot be arbitrarily high non-local correlation among any subset of the parties. We call this feature, \textit{complementarity of genuine multipartite non-locality}. We use Svetlichny's criterion for genuine multipartite non-locality and non-local games to derive the complementarity relations under no-signaling constraints. We find that the complementarity relations are tightened for the much stricter quantum constraints. We compare this notion with the well-known notion of \textit{monogamy of non-locality}. As a consequence, we obtain tighter non-trivial monogamy relations that take into account genuine multipartite non-locality. Furthermore, we provide numerical evidence showcasing this feature using a bipartite measure and several other well-known tripartite measures of non-locality.

Steady-state generation of maximal entanglement in any dimension via incoherent contact to thermal baths

Armin Tavakoli, Jonatan Bohr Brask, Geraldine Haack, Nicolas Brunner and Marcus Huber

Speaker: Armin Tavakoli 03.10.2017, 16:45 Poster

We present a simple thermal machine in which two (d+1)-level quantum systems interact through resonant transitions, as well as through weak incoherent interactions with a hot and cold thermal bath respectively. The machine is autonomous, meaning that it has no source of external control or coherence. We show that one can probabilistically generate two maximally entangled d-level systems from the resulting steady state of the autonomous thermal machine.

Routing entanglement in a quantum network

Axel Dahlberg and Stephanie Wehner

Speaker: Axel Dahlberg 03.10.2017, 16:45 Poster

Entanglement is a crucial resource in quantum communication, but producing entanglement in a quantum network is generally a costly process. It would therefore be useful if already existing entanglement in the network can be recycled. Consider for example the case where a subset of the parties in the network wish to run some protocol, for example a secret sharing or anonymous transfer protocol, which requires a GHZ-state shared between these parties. A natural question is then whether this GHZ-state can be produced from the current state in the network, by performing local operations.

In this work we focus on transforming graph states by local Clifford operations and local Pauli measurements. In particular we consider the question of whether a graph state, the target state, can be reached from some original graph state, using these local operations. It is already well know how to efficiently decide if two graph states are equivalent under local Clifford operations. However it is not know how to do this if also local Pauli measurements are included. We solve this problem for a subclass of graphs and present an efficient algorithm that works when the target state is a GHZ-state and the original graph is distance-hereditary.

Measuring higher-dimensional entanglement

Chandan Datta, Pankaj Agrawal and Sujit Choudhary

Speaker: Chandan Datta *03.10.2017, 16:45* *Poster*

We study local-realistic inequalities, Bell-type inequalities, for bipartite pure states of finite dimensional quantum systems -- qudits. There are a number of proposed Bell-type inequalities for such systems. Our interest is in relating the value of Bell-type inequality function with a measure of entanglement. Interestingly, we find that one of these inequalities, the Son-Lee-Kim inequality, can be used to measure entanglement of a pure bipartite qudit state and a class of mixed two-qudit states. Unlike the majority of earlier schemes in this direction, where number of observables needed to characterize the entanglement increases with the dimension of the subsystems, this method needs only four observables. We also discuss the experimental feasibility of this scheme. It turns out that current experimental set ups can be used to measure the entanglement using our scheme.

Superradiance of Classical Fields via Projective Measurements

Daniel Bhatti, Steffen Oppel, Ralph Wiegner, Girish S. Agarwal and Joachim von Zanthier

Speaker: Daniel Bhatti *03.10.2017, 16:45* *Poster*

We study the state evolution of the fields produced by classical sources, when recording intensity correlations of higher order in a generalized Hanbury Brown and Twiss setup [1,2]. Apart from an offset, we find that the angular distribution of the last detected photon is identical to the superradiant emission pattern generated by an ensemble of two-level atoms in entangled symmetric Dicke states. As a consequence, we demonstrate that the Hanbury Brown and Twiss effect, originally established in astronomy to determine the dimensions or separation of stars, and Dicke superradiance, commonly observed with atoms in highly entangled Dicke states, are two sides of the same coin. We show that the phenomenon derives from projective measurements induced by the measurement of photons in the far field of the sources and the permutative superposition of quantum paths identical to those leading to superradiance in the case of single photon emitters [3].

[1] S. Oppel, et al., Phys. Rev. Lett. 113, 263606 (2014).

[2] D. Bhatti, et al., Phys. Rev. A 94, 013810 (2016).

[3] R. Wiegner, et al., Phys. Rev. A 92, 033832 (2015).

Controlling adsorbate distributions on a silica-coated gold surface measured by Rydberg spectroscopy

David Davtyan

Speaker: David Davtyan *03.10.2017, 16:45* *Poster*

We trap atomic ensembles in a two-dimensional array of Ioffe-Pritchard type magnetic microtraps above an atom chip, with the goal of inducing interaction between Rydberg atoms. Due to adsorbate Rb atoms on the chip Rydberg excitations are shifted and broadened due to stray electric fields. We use Rydberg spectroscopy to measure these electric fields and gradients, and their dependence on the distance to the surface [1].

We also demonstrate a method to control electric fields by mild local heating using the blue Rydberg excitation laser, which changes the distribution of adsorbed atoms on the silica layer. This method allows us to reduced the stray electric to less than 2 V/cm at 61 um distance.

[1] J. Naber et al., J Phys B, Vol.49 N. 9 (2016)

Complementary Relations Between Quantum Steering Criteria

Debasis Mondal and Dagomir Kaszlikowski

Speaker: Debasis Mondal *03.10.2017, 16:45* *Poster*

Recently, a connection between quantum coherence and quantum steering was established and criteria for non-local advantage of quantum coherence were derived. Here, we derive a set of complementarity relations between the non-local advantages of quantum coherence achieved by various criteria.

Non-Markovian time evolution of an accelerated qubit

Dimitris Moustos and Charis Anastopoulos

Speaker: Dimitris Moustos *03.10.2017, 16:45* *Poster*

We present a new method for evaluating the response of a moving qubit detector interacting with a scalar field in Minkowski spacetime. We treat the detector as an open quantum system, but we do not invoke the common Markov and Rotating Wave approximations. The evolution equations for the qubit density matrix are valid at all times, for all qubit trajectories, and they incorporate non-Markovian effects. We analyze in detail the case of uniform acceleration, providing a detailed characterization of all regimes where non-Markovian effects are significant. We argue that the most stable characterization of acceleration temperature refers to the late time behavior of the detector because interaction with the field vacuum brings the qubit to a thermal state at the Unruh temperature. In contrast, the early-time transition rate, that is invoked in most discussions of acceleration temperature, does not exhibit a thermal behavior when non-Markovian effects are taken into account. Furthermore, we note that the non-Markovian evolution derived here also applies to the mathematically equivalent problem of a static qubit interacting with a thermal field bath. Finally, we discuss the implications of our results for the treatment of a moving qubit interacting with an electromagnetic field.

Optimising practical entanglement distillation

Filip Rozpedek, Thomas Schiet, Le Phuc Thinh, David Elkouss, Andrew C. Doherty and Stephanie Wehner

Speaker: Filip Rozpedek *03.10.2017, 16:45* *Poster*

The goal of entanglement distillation is to turn a large number of weakly entangled states into a smaller number of highly entangled ones. Practical entanglement distillation schemes offer a tradeoff between the fidelity to the target state, and the probability of succesful distillation. Exploiting such tradeoffs is of interest in the design of quantum repeater protocols. Here, we present a number of methods to assess and optimise entanglement distillation schemes. We start by giving a numerical method to compute upper bounds on the maximum achievable fidelity for a desired probability of success. This can be used to asses how well specific entangled states can be distilled in quantum network protocols. We show that this method performs well for many known examples by comparing it to well known distillation protocols. Indeed, we use it to prove optimality of the DEJMPS and EPL protocols for specific input states of interest. We proceed to present a method that can improve an existing distillation scheme for a given input state. An implementation of our numerical methods is available as an Julia package.

A quantum particle in a cavity with alternating boundary conditions

Giancarlo Garnero and Paolo Facchi

Speaker: Giancarlo Garnero *03.10.2017, 16:45* *Poster*

We consider the quantum dynamics of a non-relativistic free particle moving in a cavity and we analyze the effect of a rapid switching between two different boundary conditions. We show that this procedure induces, in the limit of infinitely frequent switchings, a new effective dynamics in the cavity related to a novel boundary condition. We explicitly compute the novel boundary condition in terms of the two initial ones. With this procedure we define a dynamical composition law for boundary conditions.

On-chip generation of frequency-entangled qudits

Giorgio Maltese, Giulia Sinnl, Aristide Lemaitre, Florent Baboux, Maria Amanti and Sara Ducci

Speaker: Giorgio Maltese *03.10.2017, 16:45* *Poster*

The generation and manipulation of high-dimensional entangled states of light on a miniaturized chip is a cornerstone for quantum information technologies [1]. Among the different platforms under study, AlGaAs-based devices attract a considerable interest thanks to their compliance with electrical injection [2] and electro-optic effect.

Here we demonstrate AlGaAs waveguides emitting photon pairs with a high rate (2.37MHz) and a signal-to-noise ratio up to 5e4. This result potentially brings us in the condition of achieving a 0.99 fidelity to a maximally entangled state.

Our devices are based on a modal phase-matching scheme and emit orthogonally polarised twin photons at 1560nm. The dispersion properties of our devices, together with the modal reflectivity on the waveguide facets, lead to the generation of a biphoton state with a comb-like joint spectral amplitude, corresponding to frequency-entangled Qudits. The emission of an entangled Qudit state is supported by the measurements of the Joint Spectral Intensity and Hong-Ou-Mandel interference. Contrary to recent experiments requiring external filter or cavities to engineer the target state, our devices represent a miniaturized source, working at room temperature and telecom wavelength.

[1] M. Kues et. al., Nature 546, 622-626, (2017)

[2] F. Boitier et al., Phys. Rev. Lett 112, 183901, (2014)

Randomness, Indistinguishability and the Environment as a Quantum Turing Machine

Hany Elemy

Speaker: Hany Elemy *03.10.2017, 16:45* *Poster*

The relentless attempts to contrive an all-comprehensive definition of randomness will always confront the complete bereft of mathematical reasoning that should meticulously delineate a conspicuous meaning of the word itself. However, solace could be found in the indecisiveness inherent to some dynamical physical processes, where the incorporation of noise within the mathematical framework of these processes will help us develop a similarity relationship among them all. On a practical level, the direct consequence of this established equivalency will be state preparation and environment engineering. Moreover, we will introduce a cheaper alternative to true random number generators. We believe that such analytical perspective will substantially embody the true identity of randomness.

Quantum dot implementation of large error correction codes

Jonas Helsen, Mark Steudtner, Menno Veldhorst and Stephanie Wehner

Speaker: Jonas Helsen *03.10.2017, 16:45* *Poster*

The size of quantum computing systems is set to increase rapidly in the near term future. Recently we made a proposal for a large scale quantum processor to be implemented in silicon quantum dots. This system features a crossbar control architecture which limits parallel single qubit control, but allows the scheme to overcome scaling issues that form a major hurdle to large scale quantum computing systems. In this work, we develop an assembly language that makes it possible to easily map quantum circuits to the crossbar system, taking into account its planar architecture and control limitations. Using this assembly language we show how to implement well known quantum error correction codes such as the planar surface and color codes in this limited control setting with only a small overhead in time. Finally, using the quantum dot processor's ability to shuttle qubits around we develop a planar implementation of the 3D gauge color code, an error correction code that allows for universal fault tolerant quantum computing without the need for methods such as magic state distillation.

Scalability of quantum memory

Joris Kattemölle

Speaker: Joris Kattemölle *03.10.2017, 16:45* *Poster*

Why are cats never in a superposition of dead and alive? Usually, it is argued that decoherence makes sure that cats are never in a superposition: since the coherence time scales unfavourable with the size of the system, and because cats are relatively large, their coherence time is nihil. As quantum memory is scaled up, we are bound to encounter the same effects of the quantum-to-classical-transition.

One of the proposed solutions is to hide the quantum information in a subspace of the quantum register that is invulnerable to any noise. States in this subspace will not decohere, and therefore such a subspace is called a 'Decoherence Free Subspace' (DFS). These DFS's were shown to be stable under first order perturbations of the noise, which means that if the noise differs slightly from what you expected it to be, the decoherence of states in the DFS is still negligible. However, we show that the second order effects still scale unfavourably with the number of qubits, which puts new limits on effectiveness with which DFS's can be used to overcome decoherence.

Covert quantum internet

Kamil Bradler, George Siopsis and Alex Wozniakowski

Speaker: Alex Wozniakowski *03.10.2017, 16:45* *Poster*

We apply covert quantum communication based on entanglement generated from the Minkowski vacuum to the setting of quantum computation and quantum networks. Our approach hides the generation and distribution of entanglement in quantum networks by taking advantage of relativistic quantum effects. We devise a suite of covert quantum teleportation protocols that utilize the shared entanglement, local operations, and covert classical communication to transfer or process quantum information in stealth. As an application of our covert suite, we construct two prominent examples of measurement-based quantum computation, namely the teleportation-based quantum computer and the one-way quantum computer. In the latter case we explore the covert generation of graph states, and subsequently outline a protocol for the covert implementation of universal blind quantum computation.

Quantum Streaming Algorithms for Online Minimization Problems and Quantum Online Algorithms with Advice

Kamil Khadiev, Aliya Khadieva and Ilnaz Mannapov

Speaker: Kamil Khadiev *03.10.2017, 16:45* *Poster*

A streaming algorithm is a well-known computational model that has a relationship with automata and branching programs models. We consider a quantum version of streaming algorithms for solving online minimization problems (OMP). It is the first time when quantum streaming algorithms are explored for solving such problems. And we also can consider this model as a quantum online algorithm with restricted memory. In the paper, we show that quantum streaming algorithms for OMP can be better than classical ones (deterministic or randomized) for sub-logarithmic and poly-logarithmic space (memory), and they can be better than deterministic online algorithms without restriction for memory. Another point of view to the online algorithms model is advice complexity. So, we introduce quantum online algorithms with a quantum channel with an adviser. Firstly, we show that quantum algorithms have at least the same computational power as classical ones have. Secondly, we consider quantum online algorithms that share entangled qubits with an adviser. We show that these algorithms can use twice less advise qubits comparing to classical counterparts.

Improving the dissipative production of a maximally entangled state via optimal control

Karl Horn and Christiane Koch

Speaker: Karl Horn *03.10.2017, 16:45* *Poster*

Being able to successfully implement quantum information processing in practice hinges on the reliable generation of entanglement, which remains a challenge for even the most modern experimental techniques. Contrary to the usual approach of shielding the quantum system from its environment, dissipative techniques attempt to deliberately incorporate dissipation into the system dynamics, inherently stabilising it against detrimental effects of the environment. The feasibility of generating steady state entanglement between two trapped beryllium ions, by utilising a dissipative mechanism, has been experimentally demonstrated [1]. Ultimately, the success of the above approach is hampered by limitations associated with its particular implementation. We therefore propose two modifications to the original beryllium ion scheme, leading to improved entanglement whilst respecting current experimental limitations. Optimising the polarisation of the laser beams utilised in the experiment is a first step towards improvement of the entanglement fidelity. More significantly, it is possible to drive alternate combinations of transitions between internal states of the beryllium ions. We have found a specific combination of transitions, which when combined with optimised polarisation, enables both faster entanglement and an increase in the attained fidelity by an order of magnitude.

[1] Lin Y. et al. Nature 504, 415 (2013)

Nonclassicality in optical systems

Kishore Thapliyal and Anirban Pathak

Speaker: Kishore Thapliyal 03.10.2017, 16:45 Poster

Possibility of generating several nonclassical states various optical systems, such as nonlinear optical couplers [1,2] and hyper-Raman process [3], is studied. Specifically, the presence of nonclassical states is investigated in an asymmetric nonlinear optical coupler, composed of one linear and one nonlinear (χ^{2}) waveguides, for both codirectional [1] and contradirectional [2] propagation of fields. Additionally, most general form of hyper-Raman process is also studied [3]. Interestingly, both lower and higher order squeezing, antibunching and entanglement have been observed in all cases. Further, quantum Zeno and anti-Zeno effects are observed in the symmetric [4] (with both nonlinear ($\chi^{2}-\chi^{2}$) waveguides) optical couplers. A completely quantum mechanical model has been used to describe all the systems considering all the field modes involved to be weak. Heisenberg's equations of motion for all the modes are obtained and Sen-Mandal perturbative technique was used to obtain closed form analytic expressions of evolution of all the field modes [1-4].

[1] K. Thapliyal, et al., Phys. Rev. A 90, 013808 (2014). [2] K. Thapliyal, et al., Phys. Lett. A 378, 3431 (2014). [3] K. Thapliyal, et al., Nonclassicality in hyper-Raman process, Communicated (2017). [4] K. Thapliyal, et al., Phys. Rev. A 93, 022107 (2016).

Communication complexity for mixed protocols

Maharshi Ray

Speaker: Maharshi Ray 03.10.2017, 16:45 Poster

We study the communication complexity of computing a function f in expectation. This requires Alice and Bob on inputs x and y respectively to output a nonnegative number whose expectation is f(x,y). The goal is to use as little communication as possible. It is known in literature that the number of classical bits needed is exactly characterised by the logarithm of the non-negative rank of the communication matrix. Similarly, the number of qubits that needs to be communicated is characterised by the logarithm of the positive-semidefinite rank of the communication matrix. We call protocols 'mixed' if we allow classical bits followed by qubits to be communicated during the protocol. We introduce a notion of rank and exactly characterise the communication complexity in expectation for mixed protocols using this rank.

We also study the correlation generation problem, where we have two random variables X and Y and Alice and Bob have to sample values from X and Y according to their joint probability distribution. We again use the above notion of rank to characterise the amount of information in terms of the number of bits and qubits that must be communicated for a mixed protocol to generate a given correlation.

Quantum batteries

Mariia Gumberidze, Michal Kolář and Radim Filip

Speaker: Mariia Gumberidze 03.10.2017, 16:45 Poster

Batteries operating on quantum scale are of huge interest nowadays. We investigate the process of charging a quantum battery, a system represented by two qubits in our work. These two qubits define a four-level system from the energetic point of view. We use incoherent quantum states as the initial state of our battery, manipulated by filtering procedures. The filtering operation consists of application of projective measurement and subsequent conditioning on certain outcome of the measurement. Applying filtering procedures to different levels of the system, we find that filtering out the ground state gives us increase in the energy of the system, which is analogous to the process of charging the battery. Moreover, for some values of the relevant parameters of the system, the entropy of the battery is decreased as well, compared to the initial state. We compare the results obtained for the incoherent initial states of the battery with those obtained from the filtering procedure applied to the pure initial quantum states of the battery.

Trading qubit resources for quantum simulation of electronic sytems

Mark Steudtner and Stephanie Wehner

Speaker: Mark Steudtner 03.10.2017, 16:45 Poster

The accurate simulation of molecular systems is one of the great promises of the coming age of quantum computers. With small scale quantum computers beginning to emerge, this goal appears to be close at hand. However, many challenges remain. One of them is the high number of qubits required for simulating molecules in the formalism of second quantization: a problem that is quite severe for state-of-the-art quantum processors. In this work, we develop methods that allow us to trade qubit resources for algorithmic complexity. The main idea behind our efforts is to encode molecular configurations as quantum states, where the amount of qubits required is reduced by accounting for Hamiltonian symmetries like particle number conservation. For that purpose, different codes are introduced that eliminate a constant, linear and exponential amount of qubits with respect to the system size. For any code in general, it is demonstrated how to transform operators of the molecular Hamiltonian into gate sequences. We expect our work to be relevant for near-term quantum simulation experiments, but also in the longer term as logical qubits are expected to remain a scarce resource for the foreseeable future.

High magnetic field gradient tips for single spin resonance imaging

Philipp Scheiger, Thomas Oeckinghaus, Rainer Stoehr, Amit Finkler and Joerg Wrachtrup

Speaker: Philipp Scheiger *03.10.2017, 16:45* *Poster*

Due to its high sensitivity to small magnetic fields at room temperature, the nitrogen-vacancy center (NV center) in diamond is a promising tool for resonance imaging of single electron spins in molecules using atomic force microscopy (AFM) techniques under ambient conditions. Using the spin-labels in molecules, the only limitation in imaging single spins in molecules with the NV center, is the spatial resolution. Every electron spin in resonance with the measurement scheme contributes to the signal and thereby reduces the probability of detecting single spins. The aim of this work is to spatially restrict the number of resonant electron spins by using a strong magnetic field gradient. Since strong off -axis magnetic fields disturb the optical readout of the NV center spin state, we try to fabricate magnetic tips with low total magnetic field strength but with a gradient in the range of 10G/nm. Commercially available magnets, like AFM tips, do not generate such fields. This work is split up into three steps, first the micromagnetic simulation of the required geometry, secondly the fabrication of high gradient magnetic on tips and finally the integration of such tips into an AFM setup for easurements with an NV center.

Photon reflection by a quantum mirror: A wave-function approach

Raul Corrêa and Pablo L. Saldanha

Speaker: Raul Corrêa *03.10.2017, 16:45* *Poster*

We derive from first principles the momentum exchange between a photon and a quantum mirror upon reflection, by considering the boundary conditions imposed by the mirror surface on the photon wave equation. We show that the system generally ends up in an entangled state, unless the mirror position uncertainty is much smaller than the photon wavelength, when the mirror behaves classically. Our treatment leads us directly to the conclusion that the photon momentum has the known value h/λ. This implies that when the mirror is immersed in a dielectric medium the photon radiation pressure is proportional to the medium refractive index n. Our work thus contributes to the longstanding Abraham-Minkowski debate about the momentum of light in a medium. We interpret the result by associating the Minkowski momentum (which is proportional to n) with the canonical momentum of light, which appears naturally in quantum formulations. DOI: https://doi.org/10.1103/PhysRevA.93.023803

Quantum simulators for open quantum systems using quantum Zeno dynamics

Sabrina Patsch and Christiane Koch

Speaker: Sabrina Patsch *03.10.2017, 16:45* *Poster*

A watched quantum arrow does not move. This effect, referred to as the quantum Zeno effect, arises from a frequent measurement of a quantum system's state. In more general terms, the evolution of the quantum system can be confined to a subspace of the system's Hilbert space leading to quantum Zeno dynamics. Resulting from the measurement process, a source of dissipation is introduced into the systems dynamics. However, different than for a common open quantum system, we can choose the strength of the dissipation by changing the parameters of the Zeno measurement.

We capitalise on the property of tunable dissipation to create a quantum simulator for open quantum systems. Due to the formal analogy of the measurement process and the theory of open quantum systems, we can derive a Lindblad master equation to describe the evolution of the open quantum system. Moreover, we extend the picture to enable also non-Markovian evolution in the quantum simulator.

The considered quantum system are photons inside a cavity being subject to a indirect measurement using circular Rydberg atoms. The setup is inspired by Zeno experiments proposed in the framework of cavity quantum electrodynamics [1].

[1] Raimond et al. Phys. Rev. A 86, 032120 (2012)

Mutual Uncertainty, Conditional Uncertainty and Strong Sub-Additivity

Sheikh Sazim, Satyabrata Adhikari and Arun Kumar Pati

Speaker: Sheikh Sazim *03.10.2017, 16:45* *Poster*

Using the variance based uncertainty, we introduce a new concept called as the mutual uncertainty between two observables in a given quantum state which enjoys similar features like the mutual information for two random variables. Further, we define the conditional uncertainty and show that conditioning on more observable reduces the uncertainty. Given three observables, we prove a 'strong sub-additivity' theorem for the conditional uncertainty under certain condition. As an application, we show that for pure product two-qubit states, the mutual uncertainty is bounded by 0.586 and if it is greater than this value then it indicates that the state is entangled. For mixed two-qubit states, we prove that the mutual uncertainty for product, classical-classical, and classical-quantum state also takes a universal value 0.586. We also show how to detect quantum steering using the mutual uncertainty between two observables. Our results may open up a new direction of exploration in quantum theory and quantum information using the mutual uncertainty, conditional uncertainty and the strong sub-additivity for multiple observables.

Multiplexed entanglement generation over quantum networks using multi-qubit nodes

Suzanne B. van Dam, Peter C. Humphreys, Filip Rozpedek, Stephanie Wehner and Ronald Hanson

Speaker: Filip Rozpedek *03.10.2017, 16:45* *Poster*

Quantum networks distributed over distances greater than a few kilometers will be limited by the time required for information to propagate between nodes. We analyze protocols that are able to circumvent this bottleneck by employing multi-qubit nodes and multiplexing. For each protocol, we investigate the key network parameters that determine its performance. We model achievable entangling rates based on the anticipated near-term performance of nitrogen-vacancy centres and other promising network platforms. This analysis allows us to compare the potential of the proposed multiplexed protocols in different regimes. Moreover, by identifying the gains that may be achieved by improving particular network parameters, our analysis suggests the most promising avenues for research and development of prototype quantum networks.

Quantum Sci. Technol. 2 034002 (2017), doi:10.1088/2058-9565/aa7446

Semiclassical Laser Cooling Near the Focal Point of a Parabolic Mirror

Thorsten Haase and Gernot Alber

Speaker: Thorsten Haase *03.10.2017, 16:45* *Poster*

Laser cooling is a widely used technique in experiments in quantum optics and information. For the most purposes of cooling above the Doppler limit laser fields are used which can be modelled by plane running waves. In this regime, the interaction between electromagnetic field and particles, modelled as two level systems, is well explained by the semiclassical theory of Doppler cooling. Nevertheless, already in the semiclassical regime standing waves give rise to different cooling properties as in the running wave case[Ci92]. Experiments conducted in Erlangen investigate the coupling between the electromagnetic field and a trapped particle near the focus of a parabolic mirror. Around the focus, the reflected and focused field mimics the time-inverted mode pattern of a spontaneous decay which enhances the excitation probability. In this setup, interactions of strongly focused standing waves with the trapped particle have to be considered. We developed a semiclassical theory which, in contrast to the usual theory of Doppler cooling, includes both. We will present stochastic simulations of the steady states of the particle distribution inside the parabolic mirror for different field intensities and simulations of saturation measurements which can be compared with experiments.

[Ci92] Cirac et.al,Phys.Rev.A,Vol.46,No.5,Sep 1992,2668-2681

Robust self-testing of (almost) all pure two-qubit states

Tim Coopmans, Jedrzej Kaniewski and Christian Schaffner

Speaker: Tim Coopmans *03.10.2017, 16:45* *Poster*

In a Bell experiment, certain extremal correlations (summarized in the Bell value) between the joint input and output of the players almost uniquely identify the quantum state they share. This phenomenon is known as self-testing and has applications in quantum cryptography with untrusted devices. For practical applications, self-testing statements need to be robust to noise. We extend previous work on self-testing of pure two-qubit states. First, we use a family of Bell inequalities called tilted CHSH inequalities to improve the robustness of previously found self-testing statements for (almost) all pure partially-entangled two-qubit states. Our result is obtained using a recently developed method of deriving self-testing statements from operator inequalities. Furthermore, we construct a bipartite state with the following two properties: (a) it violates the CHSH inequality, and (b) there exist no local quantum channels that the two players could apply to their state to achieve greater singlet fidelity than a trivial lower bound (i.e. the singlet fidelity achievable using a separable state). This result implies that there exists a threshold violation below which the players cannot `extract' a singlet from their state by just local operations. Future research will focus on extending our results to GHZ-states and on quantum steering.

Entanglement and (in)distinguishability

Ugo Marzolino

Speaker: Ugo Marzolino *03.10.2017, 16:45* *Poster*

We distilled different definitions of entanglement of identical particles from works discussed in quantum information literature. We compare them on the basis of some physical principles. One is that entanglement, as any physical correlation between particles, cannot be created by local operations, in physical terms without interactions. The second principle is that the theory of entanglement of identical particles must be consistent with the theory for distinguishable particles, when the physical description of the latters effectively emerge from the framework of identical particles, e.g. when identical particles are effectively distinguished by means of unambiguous properties. The last requirement is that, in the absence of other genuinely quantum effects, entanglement captures quantum enhanced performances in information processing. We find that the only notion of entanglement that is fully consistent with the above principles is the so-called mode-entanglement, e.g. entanglement between modes in the Fock space, which is in turn an application of a more general framework where entanglement is defined through non-classical correlations between subalgebras of observables.

Survival of time-evolved quantum correlations depending on whether quenching is across a critical point in an XY spin chain

Utkarsh Mishra, Debraj Rakshit and R. Prabhu

Speaker: Utkarsh Mishra *03.10.2017, 16:45* *Poster*

The time dynamics of quantum correlations in transverse anisotropic XY spin chain is studied at zero and finite temperatures. The evolution is due to the quenching of the couplings between the nearest-neighbor spins of the model, which is performed either within the same phase or across the quantum phase-transition point connecting the order-disorder phases of the model. We characterize the time-evolved entanglement and quantum discord, which exhibit varying behavior depending on the initial state and the quenching scheme. We show that the system is endowed with enhanced nearest-neighbor bipartite quantum correlations compared to that of the initial state, when quenched from the ordered to the deep disordered phase. However, nearest-neighbor quantum correlations are almost washed out when the system is quenched from the disordered to the ordered phase with the initial state being at the zero temperature. We find the condition for the occurrence of enhanced bipartite correlations when the system is quenched within the same phase. Moreover, we investigate the bipartite quantum correlations when the initial state is a thermal equilibrium state with finite temperature, which reveals the effects of thermal fluctuation on the phenomena observed at zero temperature.

Many-box locality

Yuqian Zhou, Yu Cai, Jean-Daniel Bancal, Fei Gao and Valerio Scarani

Speaker: Yu Cai *03.10.2017, 16:45* *Poster*

As opposed to the abstract Hilbert space formalism, the search for a more physical, or operational definition of quantum mechanics is an ongoing task. In the framework of no-signalling theories, one could try to find the set of physical principles that would allow exactly the set of quantum correlations. One of the such principles proposed is Macroscopic Locality (ML); it is shown to coincide with the first level of the Navascues-Pironio-Acin hierarchy (Q1) and known to be strictly larger than the quantum set.

In this work, we propose a refinement of the principle of ML, called Many-box locality (MBL). Denote the a bipartite two-input two-output distribution p(ab|xy) (a box), where a,b=0,1. Imagine N such independent boxes, we define the N-box coarse-graining of p(ab|xy) to be the distribution of the sums of output, p(AB|xy), where A=sum_i a_i. A distribution belongs to MBL_N if its N-box coarse-graining is local. We characterized the MBL_N sets for small number of N for several slices of the no-signalling polytope. On some slices, we showed that MBL_inf coincides with Q1; while on another, there exists a super-quantum distribution that falls in MBL_inf.

Generalized non-Markovian stochastic Schrödinger equation with application to entanglement detection

Nina Megier, Walter Strunz, Carlos Viviescas and Kimmo Luoma

Speaker: Kimmo Luoma *03.10.2017, 16:45* *Poster*

We construct a class of non-Markovian stochastic Schrödinger equations (SSE) driven by complex valued colored non-circular Gaussian noise. Instead of postulating the noise correlations, we show how the statistics of the noise process emerge from quantum measurements done on the the environment. We carefully discuss the Markov limit and obtain a SSE compatible with the Lindblad-Gorini-Kossakowski-Sudarshan quantum master equation. Lastly, we present an application to optimal entanglement detection in the presence of quantum memory effects.

Interferometer alignment method based on the weak value concept

Katharina Senkalla, Jan Dziewior, Lukas Knips, Demitry Farfurnik, Jonathan Efroni, Nimrod Benshalom, Shimshon Bar-Ad, Lev Vaidman, and Harald Weinfurter

Speaker: Katharina Senkalla *03.10.2017, 16:45* *Poster*

For a variety of experiments, interferometers are an important tool. Frequently, the precise alignment of the two beams of the interferometers is one of the most time consuming parts of an optical experiment. We provide an easy alignment technique based on the weak value concept which requires only a single position sensitive detector to resolve deviations both in position and direction. For that purpose, we utilize the phase dependence of the average position of the interference pattern, which is directly related to the weak value. Analyzing the position data over a 2π phase scan yields the changes to be applied to the position and the angle of the interferometer beams. With this method, the best overlap between the coherent components of both beams can be achieved with a single detector within a few experimental runs.

Abstracts 04.10.2017

Realization of Shor's algorithm at Room Temperature

Niklas Johansson and Jan-Åke Larsson

Speaker: Niklas Johansson *04.10.2017, 10:30* *Talk*

Shor's algorithm can find prime factors of a large number more efficiently than any known classical algorithm. Understanding the properties that gives the speedup is essential for a general and scalable construction. Here we present a realization of Shor's algorithm, that does not need any of the simplifications presently needed in current experiments and also gives smaller systematic errors than any former experimental implementation. Our realization is based on classical pass-transistor logic, runs at room temperature, and uses the same amount of resources as a scalable quantum computer. In this paper, the focus is not on the result of the factorization, but to compare our realization with current state-of-the-art experiment, factoring 15. Our result gives further insight to the resources needed for quantum computation, aiming for a true understanding of the subject.

Towards quantum simulation with circular Rydberg atoms

Thanh-Long Nguyen, Tigrane Cantat-Moltrecht, Brice Ravon, Rodrigo Cortiñas, Clément Sayrin, Serge Haroche, Michel Brune and Jean-Michel Raimond

Speaker: Brice Ravon *04.10.2017, 10:45* *Talk*

Quantum simulation offers the possibility to understand phenomena involved in many-body physics. Because of the size of the relevant Hilbert space quantum phase transitions and transport are out of reach from both numerical and analytical treatment, even for supercomputers, when the system involves a few tens of spins. Numerous platforms have been developed to study quantum spin-1/2 systems. We propose a new platform to simulate a Heisenberg XXZ spin chain based on the laser-trapping of circular Rydberg atoms. Benefiting from their long intrinsic lifetime and inhibiting their microwave spontaneous emission, we expect to prepare a defect-free chain of 40 atoms having a lifetime of a few seconds. This versatile simulator provides tunability of all its parameters over the entire range of interest allowing us to follow the dynamics over 10^5 interaction cycles. This promising platform would open the way to simulations beyond the grasp of classical computation.

Quantum mechanics and the efficiency of simulating classical complex systems

Carlo Di Franco

Speaker: Carlo Di Franco *04.10.2017, 11:00* *Talk*

The development of tools allowing us to infer models from observed data, and thus to simulate possible future outputs, has a central role in several fields. Many fundamental questions in nature and society can be addressed only by isolating indicators of future behavior in highly complex systems. However, even the most efficient constructions often require information about the past that is uncorrelated with future predictions. In terms of energetic costs, this brings a waste of resources in the computer simulations based on such models. Even if the systems to simulate are completely classical, it has been proved that quantum information can reduce this waste beyond classical limits.

During the talk I will sketch this scenario, and present some of the aforementioned results. In particular, I will describe a theoretical proposal for the possible implementation of a quantum model that breaks this classical bound. Such proposal exploits tools and schemes already used for the implementation of quantum walks in linear-optics setups, and has been now experimentally demonstrated in a lab.

Flow Ambiguity: A Path Towards Classically Driven Blind Quantum Computation

Atul Mantri, Tommaso Demarie, Nicolas Menicucci and Joseph Fitzsimons

Speaker: Atul Mantri *04.10.2017, 11:15* *Talk*

Blind quantum computation protocols allow a user to delegate a computation to a remote quantum computer in such a way that the privacy of their computation is preserved, even from the device implementing the computation. To date, such protocols are only known for settings involving at least two quantum devices: either a user with some quantum capabilities and a remote quantum server or two or more entangled but noncommunicating servers. In this work, we take the first step towards the construction of a blind quantum computing protocol with a completely classical client and single quantum server. Specifically, we show how a classical client can exploit the ambiguity in the flow of information in measurement-based quantum computing to construct a protocol for hiding critical aspects of a computation delegated to a remote quantum computer. This ambiguity arises due to the fact that, for a fixed graph, there exist multiple choices of the input and output vertex sets that result in deterministic measurement patterns consistent with the same fixed total ordering of vertices. This allows a classical user, computing only measurement angles, to drive a measurement-based computation performed on a remote device while hiding critical aspects of the computation.

Fractal Properties of Magic State Distillation

Patrick Rall

Speaker: Patrick Rall *04.10.2017, 11:30* *Talk*

All quantum computers must protect quantum data from decoherence. However, the goals of data protection and data manipulation are fundamentally at odds. No error correction code can support a universal set of transversal operations, operations that we know how to implement fault-tolerantly. Luckily, an incomplete operation set can be elevated to universality by supplying certain 'magic' states. To manufacture magic states we use 'magic state distillation' to assemble many copies of low fidelity states into more useful states. Magic state distillation protocols have a complicated non-linear nature. Analysis of protocols is therefore usually restricted to one-parameter families of states which aids tractability. We show that if we lift this one-parameter restriction and embrace the complexity, distillation exhibits fractal properties. By studying these fractals we demonstrate that some known protocols are significantly more effective when not restricted. Low fidelity states that are usually worthless for distillation are now usable, and fewer iterations of the protocols are needed to reach high fidelity. Additionally we calculate the fractal dimension of some common protocols as a measure of complexity. The fractal nature of distillation also explains why it is so challenging to design protocols with desired properties.

On the implausibility of classical client blind quantum computing

Alexandru Gheorghiu, Alexandru Cojocaru, Scott Aaronson and Elham Kashefi

Speaker: Alexandru Cojocaru *04.10.2017, 11:45* *Talk*

Suppose a large scale quantum computer becomes available over the Internet. Could we delegate universal quantum computations to this server, having only classical communication between client and server, in a way that is information-theoretically blind (the server learns nothing about the input apart from its size, with no cryptographic assumptions)? We give indications that the answer is no. In more detail, we observe that if there exist information-theoretically secure classical schemes for performing universal quantum computations on encrypted data, then we get unlikely containments between complexity classes, such as BQP $\subset$ NP/poly. Moreover, we prove that having such schemes for delegating quantum sampling problems, such as Boson Sampling, would lead to unlikely upper bounds for circuits computing the permanent. We then provide a complexity theoretic upper bound for schemes allowing one round of quantum communication and polynomially many rounds of classical communication (generalizing blind quantum computation). This upper bound then lets us show that, under plausible complexity assumptions, such a protocol is no more useful than classical schemes for delegating NP-hard problems. Lastly, we comment on the implications of these results for the prospect of verifying a quantum computation through classical interaction with the server.

Remote polarization-entanglement generation by local dephasing and frequency up-conversion

Sina Hamedani Raja, Goktug Karpat, Elsi-Mari Laine, Sabrina Maniscalco, Jyrki Piilo, Chuan-Feng Li and Guang-Can Guo

Speaker: Sina Hamedani Raja 04.10.2017, 14:45 Talk

We introduce a scheme for remote entanglement generation for the photon polarization. The technique is based on transferring the initial frequency correlations to specific polarization-frequency correlations by local dephasing and their subsequent removal by frequency up-conversion. On fundamental level, our theoretical results show how to create and transfer entanglement, to particles which never interact directly. This possibility stems from the multipath interference and its control in frequency space. For applications, the developed techniques and results allow for the remote generation of entanglement with distant parties without Bell state measurements and open the perspective to probe frequency-frequency entanglement by measuring the polarization state of the photons.

Entanglement scaling at a first order phase transition

Abel Yuste and Anna Sanpera

Speaker: Abel Yuste 04.10.2017, 15:00 Talk

First order quantum phase transitions (1QPTs) are signaled, in the thermodynamic limit, by discontinuous changes in the ground state properties. These discontinuities affect expectation values of observables, including spatial correlations. When a 1QPT is crossed in the vicinity of a second order one, the increase of the correlation length associated to the later strongly modifies the properties of the corresponding ground state and it becomes increasingly difficult to determine the order of the transition when the size of the system is finite. Here we show that, in such situations, it is possible to apply finite size scaling to entanglement measures in 1QPTs, as it has recently been done for the order parameter and the energy gap to obtain the correct thermodynamic limit. We show how this finite size scaling can unambigously discriminate between first and second order phase transitions in the vicinity of multricritical point even when the singularities displayed by the measures of entanglement lead to controversial results.

Convex optimization over classes of multiparticle entanglement

Jiangwei Shang and Otfried Gühne

Speaker: Jiangwei Shang *04.10.2017, 15:15* *Talk*

A well-known strategy to characterize multiparticle entanglement utilizes the notion of stochastic local operations and classical communication (SLOCC), but characterizing the resulting entanglement classes is very difficult. Given a multiparticle quantum state, we first show that Gilbert's algorithm can be adapted to prove separability or membership in a certain entanglement class. We then present two reliable algorithms for convex optimization over SLOCC classes. The first algorithm uses a simple gradient approach, while the other one employs the accelerated projected-gradient method. For demonstration, the algorithms are applied to the likelihood-ratio test using experimental data on bound entanglement of a noisy four-photon Smolin state [Phys. Rev. Lett. 105, 130501 (2010)]. Our work not only sheds new light on the separability problem, but also provides a reliable tool for experimentalists to characterize the entanglement property of their quantum systems with confidence.

Ref: J. Shang and O. Gühne, Convex optimization over classes of multiparticle entanglement, Under review at Phys. Rev. Lett.; eprint arXiv:1707.02958 [quant-ph] (2017).

Entanglement and quantum combinatorial designs

Zahra Raissi, Dardo Goyeneche, Sara Di Martino and Karol Zyczkowski

Speaker: Zahra Raissi *04.10.2017, 15:30* *Talk*

Orthogonal Arrays(OA) are combinatorial arrangements which have close connection to error correcting codes, and Latin squares. Applications of orthogonal arrays are given in statistics and design of experiments. An r*n array A with entries taken from a set with q elements is said to be an OA with q levels, strength k and index l if every r*k subarray of A contains each k-tuple of symbols exactly l times as a row.

I will have an overview on OAs and then introduce the notion of Quantum Orthogonal Arrays(QOA) as a natural generalization of OAs. Entries of these arrangements are composed by pure quantum states where different columns are allowed to be entangled. Additionally we will see that quantum Latin squares are naturally derived from QOA in the same way as Latin squares arise from OAs. It is important to discuss about the connection between the classical combinatorial arrangement to quantum mechanics, it shows how to find further applications for quantum protocols. I will demonstrate QOA of strength k composed by n columns are one-to-one connected with k-uniform states. A pure quantum state of n subsystems is called k-uniform if all its reductions to k<=floor{n/2} qudits are maximally mixed.

Efficient Device-independent Entanglement Detection for Multipartite Systems

Flavio Baccari, Daniel Cavalcanti, Peter Wittek and Antonio Acín

Speaker: Flavio Baccari *04.10.2017, 15:45* *Talk*

Entanglement is one of the most peculiar aspects of quantum theory and is a key feature for several quantum information protocols. However, detecting its presence in multipartite states remains challenging both experimentally and theoretically. The first barrier towards entanglement detection is the exponential amount of information required to reconstruct the system's state. The second, is that, even if the quantum state is known, the available methods are computationally too demanding even for systems composed of few particles. In this talk (based on [1]) I will introduce a device-independent technique for entanglement detection that is both computationally and experimentally efficient. It involves a number of experimental configurations that grows only polynomially with the size of the system, which makes it applicable to states of up to a few tens of particles. Moreover, it is based on the knowledge of few-body correlators, hence being amenable to practical implementations. I will also report several examples of implementation of the method for well-known multipartite states, showing that the introduced technique has a promising range of applications. [1] F. Baccari et al. , Phys. Rev. X 7, 021042 (2017)

Certification of quantum network functionality based on multi-round teleportation

Victoria Lipinska, Le Phuc Thinh and Stephanie Wehner

Speaker: Victoria Lipinska *04.10.2017, 16:00* *Talk*

Quantum communication is a core element of quantum information science. The most general communication scenario involves separated nodes exchanging quantum information at a large distance, which defines a quantum network. Recently, various operational stages of network functionality were defined in terms of classes of protocols that can be performed with certain resources. Importantly, there exists a class of protocols, involving e.g. blind quantum computing or generating anonymous entanglement, which crucially requires storing a quantum state while being able to perform universal local operations. However, state of the art implementations can only achieve either good local control or good quantum memory. We propose a simple testing protocol, which we call memory and control test, that provides an explicit certification of attainment of both tasks simultaneously. Specifically, we present a protocol based on multi-round teleportation in the presence of universal local gates. We adapt it to experimentally feasible scenarios, where imperfections naturally arise, and provide explicit parameters for estimating the quality of universal gates in the presence of noisy memory. Moreover, based on the test we estimate the performance of other protocols relevant for the stage.

Interference of single photons on a system of coupled waveguides

Ali Angulo, Hector Cruz Ramírez, Alfred U'Ren and Javier Alejandro Lopez Alfaro

Speaker: Ali Angulo *04.10.2017, 16:30* *Poster*

Engineering quantum states by tailoring the properties of quantum correlations can be used for several applications as quantum computation, quantum cryptography and quantum telecommunication. Using the quantum state generated by an SPDC experiment on a system of coupled waveguides we can tailor the state of couple of photons to spread the HIlbert space and make multidimensional state useful for several applications.

Simulating Markov Transition Probabilities in a Quantum Environment

Carla Silva, Marcus Dahlem and Inês Dutra

Speaker: Carla Silva *04.10.2017, 16:30* *Poster*

Quantum mechanics provides the mathematical explanation of the motion and interaction with energy at atoms level, and quantum physics allows particles to be in two states at the same time. Those are concepts that together built up quantum computing assumption. Through quantum simulators we believe faster results can be attained if conducted in a quantum-based approach in a specific environment. We performed experiments with Markov chains by modeling them into a quantum algorithm capable of being simulated on a quantum computer. We used the Google Quantum Computing Playground, a GPU-accelerated quantum computer with a 3D quantum state visualization, a browser-based WebGL Chrome using the language QScript. We implemented a Markov chain assuming that the process is homogeneous in time and built the transition matrix by estimating Markov probabilities for the states. We modeled a transition in which the process does not stay in the same state, eliminating the self-loop transitions and normalizing the remaining probabilities. We notice that sigmaX gate (quantum not) that flips states 0 and 1 for given qbit 0, and hadamard gate that creates superposition of states 0 and 1 for given qbit 2, gave us faster results than for other setting environments in a quantum level.

Optimizing Quantum Walk Search on a Reduced Uniform Complete Multi-Partite Graph

Chen-Fu Chiang and Chang-Yu Hsieh

Speaker: Chen-Fu Chiang *04.10.2017, 16:30* *Poster*

A recent work by Novo et al. (Sci. Rep. 5, 13304, 2015) shows an invariant subspace method applied to the study of continuous-time quantum walk (CTQW). This method reduces a graph into a simpler version that allows more transparent analyses of the quantum walk model. We adopt the aforementioned method to investigate the optimality of a quantum walk search of a marked element on a complete multi-partite graph. We formulate the eigenbasis that would facilitate the transport between the two lowest energy eigenstates and demonstrate how to set the appropriate coupling factor to achieve optimality. The notion of invariant subspaces of continuous-time quantum walk (CTQW) problems is a powerful technique that simplifies the analyses of various quantum walk related studies such as the spatial search algorithm, quantum transport, and quantum state transfer. In this work, we apply this technique and generalize the result from complete graphs (CG), complete bipartite-graphs (CBG) and star graphs (SG) to uniform complete multiple-partite graphs (UCMG). More specifically, we (1) derive the formula for the coupling factor and (2) show that CTQW constructed based on our choice of coupling factor will remain optimal.

Multipartite entanglement transformations with local operations and finite rounds of classical communication

Cornelia Spee, Julio de Vicente, David Sauerwein and Barbara Kraus

Speaker: David Sauerwein *04.10.2017, 16:30* *Poster*

We consider generic pure n-qubit states and a general class of pure states of arbitrary dimensions and arbitrarily many subsystems. We characterize those states which can be reached from some other state via local operations assisted by finitely many rounds of classical communication (LOCC_N). For n>3 qubits we show that this set of states is of measure zero. That is, almost no state can be reached if restricted to the practical scenario of LOCC_N. We also identify classes where any separable transformation can be realized by a protocol in which each step is deterministic. Such transformations are natural generalizations of bipartite transformations. We show, however, that in general there exist state transformations which require a probabilistic step within the protocol. This highlights the difference between bipartite and multipartite LOCC and shows that multipartite LOCC transformations are more complex than the transformations considered in the literature so far. Finally, we obtain easily computable lower bounds on some entanglement measures by restricting to LOCC_N. References: C. Spee, J. I. de Vicente, D. Sauerwein, and B. Kraus, Phys. Rev. Lett. 118, 040503 (2017) ; J. I. de Vicente, C. Spee, D. Sauerwein, and B. Kraus Phys. Rev. A 95, 012323 (2017)

Bell Inequalities in Continuous Variable Systems for General 4-mode Gaussian States

Gaurav Saxena, Chandan Sharma and Arvind Arvind

Speaker: Gaurav Saxena *04.10.2017, 16:30* *Poster*

Continuous Variable Bell Inequalities for 4-mode systems are studied. The reason for choosing 4-modes over 2-modes is due to the fact that for every propagation direction, two polarizations can be associated and with each of these four modes, annihilation operators a1, a2, a3, a4, can be associated. The inequalities used are known as multiphoton inequalities and were given by Arvind et.al in 1998. In our study, we have analyzed the non-locality of a general 4-mode Gaussian state by including noise due to a beam splitter and for different temperatures. We have also analyzed our results for different squeezing for different modes and by changing the entanglement between the modes. We also observe that with the use of beam splitter, a non-local state does not lose its character, i.e., it remains non-local. Even when we increase the leakage due to the beam splitter, i.e., we decrease the transmitivity, there is still some violation of the inequality. Hence, it can be concluded that the action of the beam splitter preserves the non-locality of the transmitted state which is our main result.

Quantum Sensor Networks with NV centers

Helmut Frasch, Durga Dasari and Jörg Wrachtrup

Speaker: Helmut Frasch *04.10.2017, 16:30* *Poster*

We develop theoretical methods for using a NV-based sensor spin network for faithful reconstruction of spatio-temporal signals originating from macroscopic samples (e.g., brain) with micro/nano scale resolution. A high degree controllability of the sensors with applied microwaves and good optical readout allows us to establish a network structure for phase acquisition on individual sensors or groups of sensors with optimized pulse sequences. Further the correlation of all encoded phases makes it possible to extract the desired spatio-temporal information with a higher sensitivity and good SNR compared to sequential measurements. We will show how the developed methods could lead to neuronal imaging with high spatial resolution on a wide frequency range. We will discuss the physical constraints for the experimental realization of this method and obtain bounds on the maximum attainable sensitivities in sensing and localizing the signal.

Entanglement in quantum spin networks with defects

Himadri Dhar

Speaker: Himadri Dhar *04.10.2017, 16:30* *Poster*

A key aspect in designing an effective and scalable quantum network is generating entanglement between its nodes, which is robust against defects in the network. We consider a bipartite quantum network of spin-1/2 particles with a finite fraction of defects, where the corresponding wave function of the network is rotationally invariant under the action of local unitaries. By using quantum information-theoretic concepts like strong sub-additivity of von Neumann entropy and approximate quantum telecloning, we prove analytically that in the presence of defects, caused by loss of a finite fraction of spins, the network, comprised of a fixed numbers of lattice sites, sustains genuine multisite entanglement, and at the same time may exhibit finite moderate-range bipartit entanglement, in contrast to the network with no defects.

Two-photon interference of vapor-delayed single quantum-dot photons

Hüseyin Vural

Speaker: Hüseyin Vural *04.10.2017, 16:30* *Poster*

Beside their enormous flux, quantum dots (QDs) allow for high photon indistinguishability and photonic entanglement generation, and their use as *flying qubits* for the quantum communication of the future. One limitation of QDs is the missing long lasting quantum memory. Here, we focus on the approach of storing light in an cesium (Cs)-vapor by slowing down single photons. High dispersion between ground-state hyperfine resonances of Cs-vapors enables lower group velocities, while maintaining transmission. Using a Cs-vapor as slow light-medium, we present a variable delay up to 27 ns for 500 ps photons from resonantly excited QD’s. Increasing the temperature in the vapor changes the dispersion, which allows us to control the amount of delay experienced by the photons. The crucial measure for implementing a quantum repeater, various quantum information protocols, and entanglement distribution is given by the single photon purity and indistinguishability. Therefore we eventually investigate the single-photon emission and compare the two-photon interference of delayed and undelayed photons.

Commercializing continuous-variable quantum key distribution

Imran Khan

Speaker: Imran Khan *04.10.2017, 16:30* *Poster*

Conventional cryptography serves as a means to protect important communication from unauthorized access. It has been shown throughout history that advances in mathematics can weaken or even break ciphers deemed secure previously. This can be remedied by finding new ciphers. If a powerful adversary however keeps the cipher ‘s weakness secret, he may use it to break existing encryption. It is also known that a powerful quantum computer renders some of the existing cryptographic algorithms insecure. A solution to this problem is quantum key distribution (QKD), which unlike conventional cryptography does not rely on assumptions of computational complexity, nor is it insecure against a quantum computer. Instead, it is based on security proofs using quantum mechanics to provide information-theoretic security. Recent advances in continuous-variable QKD demonstrated the feasibility of using existing high-speed telecom technology for its implementation. In parallel, photonic integrated circuits – mainly intended for telecommunication purposes – are being developed on a European scale using InP technology. Furthermore, first experiments have demonstrated QKD with satellites to bridge global distances. At the Max-Planck-Institute for the Science of Light, we are launching a startup that takes advantage of these developments in order to commercialize and apply QKD on a wide scale.

Estimation of CHSH Inequality for Unknown Quantum State via C-SPSA

Jean Cortés-Vega and Marco Rivera-Tapia

Speaker: Jean Cortés-Vega *04.10.2017, 16:30* *Poster*

There are various methods to optimize the violation of Bell inequalities. These are used to find the optimal measurement bases. However, most of them require to know the system state beforehand. Here we study a complementary problem, that is, to verify if an unknown quantum state can violate the CHSH inequality. In this case, conventional optimization methods can not be employed. We address this problem by using an iterative optimization algorithm named “Complex Simultaneous Perturbation Stochastic Approach” (CSPSA). This is based on an estimate of the complex Wirtinger gradient of a target function that is used to generate a sequence of complex estimates approaching the minimizer. Magnitude and direction of the gradient’s estimation are calculated as the difference between the target function evaluated at two different points and as a complex vector whose components are randomly, independently generated, respectively. We considered the CHSH inequality as the objective function. Given a starting point (i.e., a random set of observables), and if the state is able to violate the CHSH inequality, the algorithm finds the necessary measurement bases for which the unknown input quantum state maximizes its violation. We anticipate these findings can be used for assisting several experimental realizations.

New entropic functions for qubit and Gaussian states

Julio Lopez and Vladimir Man'Ko

Speaker: Julio Lopez *04.10.2017, 16:30* *Poster*

The Tsallis relative entropy $S_q (\hat{\rho},\hat{\sigma})$ measures the distance between two arbitrary density matrices $\hat{\rho}$ and $\hat{\sigma}$. In this work the approximation to this quantity when $q=1+\delta$ ($\delta\ll 1$) is obtained. It is shown that the resulting series is equal to the von Neumann relative entropy when $\delta=0$. Analyzing the von Neumann relative entropy for arbitrary $\hat{\rho}$ and a thermal equilibrium state $\hat{\sigma}=e^{- \beta \hat{H}}/{\rm Tr}(e^{-\beta \hat{H}})$ is possible to define a new inequality relating the energy, the entropy, and the partition function of the system. From this

inequality, a parameter that measures the distance between the two states is defined. This distance is calculated for a general qubit system and for an arbitrary unimodal Gaussian state.

Private key against side channel attacks

Karol Horodecki and Omer Sakarya

Speaker: Omer Sakarya *04.10.2017, 16:30* *Poster*

A private state consist of a key part AB and a shield part A'B'. The key is secure because of the fact that each private state shared by Alice and Bob has a shield. We consider the scenario where Eve has partial access to the shield of a private bit via some quantum channel (called therefore a side channel). Our goal is twofold: we first check by how much the distillable key decreases under certain side channels. Next, we propose axioms for a well protecting shield.

Multiqubit State Tomography with Finite Data

Lukas Knips, Christian Schwemmer, Nico Klein, Jonas Reuter, Geza Toth and Harald Weinfurter

Speaker: Lukas Knips *04.10.2017, 16:30* *Poster*

We show that for finite set of data the statistical nature of measurements is an almost unavoidable reason for unphysical estimates in multiqubit quantum state tomography. The usual multinomial or Poissonian noise results in eigenvalue distributions converging to the Wigner semicircle distribution for already a modest number of qubits. This fact has to be taken into account for the evaluation of tomographic data. It forms the basis to determine which eigenvalues of the raw density matrix obtained via tomography are relevant and which ones are irrelevant as they are the result of statistical effects or cannot be distinguished from it. We introduce a method to obtain a physical estimate, without using constrained optimization. This approach allows to directly obtain also error bars for both the state estimate as well as for interesting figures of merit such as the fidelity with minimal numerical effort.

Generalized Probabilistic Description of Noninteracting Identical Particles

Marcin Karczewski

Speaker: Marcin Karczewski *04.10.2017, 16:30* *Poster*

Generalized probabilistic theories (GPTs) allow to study nonclassical phenomena on a purely operational level and independently of quantum theory. Its basic idea consists in restricting the set of all imaginable measurement outcome probabilities by physically motivated principles in order to retrieve quantum predictions. For instance, the celebrated Popescu-Rohrlich box stems from a GPT investigation of correlations restricted by the nonsignaling principle.

This talk aims to introduce a GPT description of bosonic bunching in optical multiports. In particular, a Popescu-Rohrlich box analog within the realm of identical particles will be presented. Furthermore, the simplest nontrivial case of three photons bunching on a tritter (3-port) will be fully explained with straightforward principles.

Simulating boson sampling in free space

Marc-Oliver Pleinert and Joachim von Zanthier

Speaker: Marc-Oliver Pleinert *04.10.2017, 16:30* *Poster*

Boson sampling constitutes a promising model of quantum computation, which probably for the first time will show post-classical calculations, even though it is restricted and non-universal. Here, we investigate a particularly simple boson sampling device consisting of freely propagating photons of different statistics. We relate the boson sampling probabilities to correlation functions in free-space setups. We find that the structure of the multi-photon interferences and spatial correlation functions reflect exactly those occurring in boson sampling and thus are characterized by the permanent of a propagation matrix. As a result, we are able to simulate boson sampling-like computations in free space. We also investigate the computational complexity of such a setup.

SLOCC hierarchy for generic states in 2 x m x n level systems

Mariami Gachechiladze, Martin Hebenstreit, Otfried Gühne and Barbara Kraus

Speaker: Martin Hebenstreit *04.10.2017, 16:30* *Poster*

We consider three partite pure states in the Hilbert space of dimensions 2,m,n and investigate to which states a given state can be locally transformed with a non-vanishing probability. Whenever the initial and final state are elements of the same Hilbert space, the problem is solved via the characterization of the SLOCC classes. However, when considering transformations from higher to lower dimensional Hilbert spaces, a hierarchy among the states can be found. We build on results presented in [1], where a connection to linear matrix pencils has been drawn in order to study SLOCC classes in 2,m,n systems. We first show that a generic set of states of dimensions 2,m,n, where n=m is the union of infinitely many SLOCC classes. However, for n≠m, there exists a single SLOCC class which is generic. Using this result, we derive a hierarchy of SLOCC classes for generic states. We also investigate common resource states, which are those states which can be transformed to any state (not excluding any zero-measure set) in the smaller dimensional Hilbert space.

[1] E. Chitambar, C.A. Miller, and Y. Shi, J. Math. Phys. 51, 072205 (2010)

Wide Field Imaging of Atomic Spins using Nitrogen-Vacancy Centers in Diamond

Marwa Garsi, Florestan Ziem and Jörg Wrachtrup

Speaker: Marwa Garsi 04.10.2017, 16:30 Poster

Electron and nuclear magnetic resonance are essential techniques in medicine, life sciences and material sciences to obtain deep insights into composition, structure, and function of (bio-)structures. Traditional induction-based techniques achieve volume resolutions on the order of several cubic micrometers to millimeters which excludes them from being applied at the nanoscale level for label-free imaging and single-molecule analysis. To understand fundamental processes such as membrane channel transport and to resolve the structure and folding mechanisms of proteins, novel sensors are crucially required. Here, we show a nanoscale imaging technique based on nitrogen-vacancy centers in diamond towards the detection of small ensembles of electronic [1,2] and nuclear [3,4] spins at ambient conditions. Using optically detected magnetic resonance tomography in a high resolution wide-field microscopy setup we achieve a B-field sensitivity of 100 nT/√(Hz μm^2), combined with a spatial resolution of 400 nm. Our results pave the way towards understanding fundamental process at the single-molecule levels. [1] Steinert, S. et al., Nat. Commun. 4, 1607 (2013). [2] Ziem, F. C., et al., Nano Lett. 13, 4093‑8 (2013). [3] Mamin, H. J. et al., Science 339, 557 (2013). [4] Staudacher, T. et al., Science 339, 561 (2013).

Games and Monogamy in the relativistically causal correlations

Michał Kamoń

Speaker: Michał Kamoń 04.10.2017, 16:30 Poster

Recently a new paradigm for the physically realizable correlations among observables was introduced. The corresponding set of correlations includes the convex set of no-signaling correlations and extends it to include some signaling correlations when the number of parties is equal or more than three. This signaling correlations are called Relativistic Causal (RC) because they cannot be used to send information from an event to other causally preceding event in a given spacetime. Here we characterize this new resource by computing its advantage on a set of probabilistic games. First we show that for Guest your neighbor's input (GYNI) game RC boxes provide a maximum success probability which is higher than for the best no-signaling box under several different promises. Furthermore, we show that for all unique games the monogamy relation induced by that game is violated by RC correlations. On the other hand, we show that some inequalities still preserve their monogamy for RC correlations, thus showing that exist a strict hierarchy among monogamy relations. We also compute the extremal boxes for the RC correlation polytope in the three partite, two input, two output scenario.

Quantum discord between two distant Bose-Einstein condensates with Bell-like detection

Mohammad Eghbali-Arani and Vahid Ameri

Speaker: Mohammad Eghbali-Arani *04.10.2017, 16:30* *Poster*

We propose a technique that enables the creation of quantum discord between two distant nodes,each containing a cavity consist of the Bose-Einstein condensate, by applying a non-ideal Bell-like detection on the output modes of optical cavities. We find the covariance matrix of the system after the non-ideal Bell-like detection, showing explicitly that one enables manipulation of the quantum correlations, and particularly quantum discord, between remote Bose-Einstein condensates. We also find that the non-ideal Bell-like detection can create entanglement between distant Bose-Einstein condensates at the two remote sites.

Quantum Algorithm for Perfect Matching Problem

Nikolajs Nahimovs, Raqueline Santos and Kamil Khadiev

Speaker: Nikolajs Nahimovs *04.10.2017, 16:30* *Poster*

In this poster, we consider the problem of detecting an existence of perfect matching in a bipartite graph. We limit our attention to graphs embeddable into a 2D-grid. For such graphs, it is known that time complexity of the best quantum algorithm for a maximal matching problem, a more general version of the problem, is $|V|\log^2|V|$ for $|V|$ being the number of nodes. The best known deterministic algorithm has time complexity $|V|^{3/2}$. We suggest a quantum walk algorithm (QWA) with time complexity $|V|\log|V|$. Our algorithm uses recently discovered phenomena of exceptional configurations of marked vertices of QWA with the Grover’s coin. The main idea of our algorithm is as follows. We embed the original graph into a 2D-grid and mark all its vertices. The embedding is such that the marked vertices form the exceptional configuration iff the original graph has the perfect matching. We run a QWA for the 2D-grid. If the algorithm finds a marked vertex then the configuration is not exceptional and, thus, the original graph has no perfect matching. We also present preliminary results on extending the idea to bipartite graphs embeddable into other regular graphs.

Role of cross-talk in multimode continuous-variable quantum communication

Olena Kovalenko, Vladyslav C. Usenko and Radim Filip

Speaker: Olena Kovalenko 04.10.2017, 16:30 Poster

One of the ways to increase effectiveness of quantum key distribution and quantum communication in general is to use multiplexing of channels. We consider multiplexed continuous-variable quantum communication using multimode entangled states of light. We study the effect of cross-talk between the signal modes on secret key rate and entanglement which can be shared over lossy and noisy Gaussian channels. We show how presence of cross-talk between the modes destroys key and entanglement and determine the optimal state variance for given characteristics of the channel that maximizes secure key rate and entanglement. To restore security of the protocol we find a sequence of local operations that can cancel or limit the negative effect of cross-talk. We show that for channels with the same transmittance rate for all signal modes negative effects of cross-talk in principle can be fully eliminated by proper mode coupling prior to detection on the remote side. For channels with transmittance that differs for different modes, the cross-talk can be at least partially compensated by applying optimized squeezing operation before coupling on the remote side.

Generalised cluster states of mechanical oscillators for universal quantum computation

Oussama Houhou, Darren W Moore and Alessandro Ferraro

Speaker: Oussama Houhou 04.10.2017, 16:30 Poster

Mechanical oscillators are good candidates for many quantum technologies, namely continuous variables quantum computation. It had been shown in [O. Houhou, H. Aissaoui, and A. Ferraro, Phys. Rev. A 92, 063843 (2015)] that the quantum state of an array of mechanical oscillators can be engineered in order to obtain Gaussian cluster states, a resource useful in measurement based quantum computation over continuous variables. Here, we propose a protocol for the deterministic preparation of a class of non Gaussian cluster states containing both squeezed and cubic phase state elements. This cluster state is hosted in an array of mechanical oscillators of an optomechanical system consisting of a cavity mode driven by classical fields. By a suitable choice of the intensities and phases of the driving fields, the mechanics is driven towards a steady state that is the target cluster. Our protocol can generate generalised continuous variables cluster states with arbitrary size and shape by just tuning the properties of the driving fields. These cluster states allow the implementation of universal quantum computation by only performing Gaussian operations on them.

Security analysis of thermal and continuous-variable measurement-device-independent quantum key distribution incorporating finite size effects

Panagiotis Papanastasiou, Carlo Ottaviani and Stefano Pirandola

Speaker: Panagiotis Papanastasiou 04.10.2017, 16:30 Poster

As continuous-variable (CV) quantum key distribution (QKD) moves towards realistic implementations it is essential to assess the impact of finite-size (FS) effect on the security performance. In fact, in realistic situation the parties can exchange only a finite number of signals, which must be used for both estimating the channel parameters and obtaining the secret key. In this work we extend the security analysis of thermal one-way and CV measurement-device independent (MDI) QKD, including the impact of finite-size effects. In order to perform this analysis we adapt a method described in a previous work for one-way protocols with coherent states. Thermal protocols are interesting because they allow the parties to use trusted thermal noise to both increase the security performance against noisy attacks, and extend quantum private communication to frequencies of practical utility (e.g. microwave). By contrast CV-MDI-QKD is very important because it allows two parties to establish private communication even when they cannot access a direct link. This is possible exploiting an intermediate relay assisting the parties in sharing the signals. As such MDI setup represents a first step toward implementation of more complex network configuration. We found that using blocks with 10^9 signal-points can provide high-rate usable key.

Transient Response of Bistable Systems

Paul Brookes

Speaker: Paul Brookes 04.10.2017, 16:30 Poster

Bistability is a common phenomenon in driven nonlinear oscillators. For sufficiently strong drive powers there is a range of drive frequencies close to resonance over which the oscillator has two possible steady state modes of oscillation. These modes have different amplitudes and phases. Here we study bistability in a cavity coupled to a transmon qubit. The transient response of this system shows a preference for different steady states depending on the initial state of the qubit. Over time random switching between between bistable states causes the system to lose its memory of its initial state and this approach to thermal equilibrium is much longer than any time constant in the parameters of the system. This is known as critical slowing down.

Taming finite statistics for device-independent quantum information

Pei-Sheng Lin, Denis Rosset, Yanbao Zhang, Jean-Daniel Bancal and Yeong-Cherng Liang

Speaker: Pei-Sheng Lin 04.10.2017, 16:30 Poster

The device-independent approach to physics is one where conclusions are drawn directly and solely from the observed correlations between measurement outcomes. In quantum information, this approach allows one to make strong statements about the properties of the underlying devices via the observation of Bell-inequality-violating correlations. However, since one can only perform a finite number of experimental trials, statistical fluctuations necessarily accompany any estimation of these correlations. Consequently, an important gap remains between the many theoretical tools developed for the asymptotic scenario and the experimentally obtained raw data. In particular, a sensible way to estimate the underlying quantum distribution has so far remained elusive. Here, we propose a few methods to bridge this gap. Under the assumption that the experimental trials are independent and identically distributed, our methods allow one to achieve the analog of quantum state estimation in the device-independent setting by generating unique point estimates of the true quantum distribution. We further demonstrate how these estimates of the true quantum distribution can be used to provide sensible estimates of certain desired properties of the system, such as the amount of entanglement present in the measured system.

Robust and efficient control of spins in a complex (biological) environment

Philipp Konzelmann, Torsten Rendler, Andrea Zappe, Philipp Neumann, Florian Dolde, Ville Bergholm, Thomas Schulte-Herbrüggen and Jörg Wrachtrup

Speaker: Philipp Konzelmann 04.10.2017, 16:30 Poster

Nanodiamonds (ND) had been shown to be of excellent biocompatibility and additionally can host color centers. One of the most prominent representatives is the so-called nitrogen vacancy center (NV) that features, due to its unique spin system, the intrinsic capacity to sense for example magnetic or electric fields and temperature [1]. Furthermore, intense progress in functionalization of ND surface in past years promises a manifold of different applications in life science [2]. However, keeping control of the NV spin sublevel remains challenging. Especially in complex environments a ND can change for example its orientation, such that variations in excitation strength are expectable. To overcome this obstacle several techniques had been developed exhibiting a certain robustness against such fluctuations [3,4,5]. To this end, we utilize optimum control theory in combination with so-called cooperative pulse schemes [5]. In our work, we present a systematical study exploring the efficiency of such pulses for NVs in NDs. [1] R. Schirhagl et al., ARPC 65: 83-105 2014 [2] D.G. Lim et al., Int. J. Pharm. 514: 41-51 2016 [3] M. Garwood et al., JMR. 153: 155-177 2001 [4] A. M. Souza et al., PRL 106: 240501 2011 [5] M. Braun et al.., NJP 16 2014

Tripled frequency photon generation in the focus of a deep parabolic mirror in argon gas

Rojiar Penjweini, Markus Weber, Markus Sondermann and Gerd Leuchs

Speaker: Rojiar Penjweini 04.10.2017, 16:30 Poster

We investigate the generation of tripled frequency photons under the condition of very tight focusing. Our experiments show that the number of tripled frequency photons in such a scenario has fifth power dependence on the intensity of fundamental beam. Considering six-wave-mixing as the responsible process, the number of tripled frequency photons per pulse is calculated theoretically. The behavior of tripled frequency photon generation for the transition from the paraxial regime to focusing from full solid angle is studied experimentally and theoretically. We find a good qualitative agreement between the experiment and a numerical analysis.

Selection of multipartite spin states in a nuclear bath

Stefan Jesenski, Nicolas Abt, Sebastian Zaiser, Durga Dasari, Florian Kaiser, Philipp Neumann and Jörg Wrachtrup

Speaker: Stefan Jesenski 04.10.2017, 16:30 Poster

Multipartite entangled states are key for many quantum information protocols. Generation of these states and their protection against various noise sources is quintessential for successful quantum computing and sensing applications. Here we discuss the generation and characterization of multipartite entangled nuclear spin states coupled to a single Nitrogen-Vacancy center (NV) in diamond. At low temperatures, resonant optical excitation of the NV becomes possible allowing for high fidelity projective spin readout and spin initialization. In combination with spin-lifetimes many orders of magnitude higher compared to ambient conditions, generation of multipartite entangled states becomes plausible by measurement based methods. We present a scheme and evaluate the fidelities for the initialization of the nuclear spin bath of a NV center.

Nanoscale thermometry and magnetometry for a new generation of hard disk recording heads

Sven Bodenstedt, Ingmar Jakobi, Fadi El Hallak, Philipp Neumann and Jörg Wrachtrup

Speaker: Sven Bodenstedt *04.10.2017, 16:30* *Poster*

State of the art hard disk recording heads use magnetic fields to encode data as magnetization on small sectors on a recording medium. To further reduce the bits' physical size a new generation of recording heads, called Heat Assisted Magnetic Recording (HAMR) [1], applies an additional induced heat spot to reduce the coercivity of a single bit on the recording medium. Although HAMR heads are not yet available in commercial drives this technology may increase storage capacities by orders of magnitude. The development of the device hinges on suitable sensors for the nanoscale characterization of the produced heat and magnetic field. Individual nitrogen-vacancy (NV) defect centers in diamond are the ideal candidate for this task. They are both efficient single-spin magnetometers [2] and sensitive temperature sensors [3, 4] on a nanoscale dimension. Here we present our work to bring a NV nanoscale thermometer and magnetometer to the hard disk industry. Furthermore, we show possible uses of hard disk recording heads for quantum information and sensing applications. [1] M. Krayder et al., Proceedings of the IEEE, 2008 [2] I. Jakobi et al., Nature Nanotechnology, 2016 [3] P. Neumann et al., Nano Letters, 2013 [4] A. Laraoui et al., Nature Communications, 2015

Negatively charged state on phosphorus atom in the silicon quantum computer architecture

Tatiana Pavlova

Speaker: Tatiana Pavlova *04.10.2017, 16:30* *Poster*

Negatively charged donor states (D-) play the important role in quantum computing devices based on nuclear and electron spins in silicon. In particular, read-out via the D- state is two orders of magnitude faster than via the neutral donor state due to the weaker bounding of the second electron with donor. Ability to perform manipulations with single donor orbital requires the knowledge of the bound electron wave function and its modification under applied fields. Negatively charged donors have been extensively studied in bulk semiconductors, however, transport spectroscopy measurements of the field effect transistor indicate that D- states on impurities close to an interface differ qualitatively from D- states in bulk semiconductors. In the present study, we investigated theoretically the D- state in silicon near the oxide interface in uniform electric and magnetic fields, both applied perpendicular to the surface. Wave functions and the energy spectrum of donor and interface states have been obtained analytically within effective mass theory. The hybridization of the negatively charged state between the potential of its donor atom and the triangular quantum well near Si/SiO2 interface was studied. The parameters which allow to control the electron density distribution in direction perpendicular to the interface were calculated.

The problem of quantum information's transmission through a field

Theodora Kolioni

Speaker: Theodora Kolioni *04.10.2017, 16:30* *Poster*

In this paper, we investigate the transmission of information through the environment between two widely separated quantum systems, modeled as harmonic oscillators .We focus on quantum Brownian motion models in which N separated oscillators interact with a quantum scalar field. We compute the solutions for the homogeneous equation of motion and the dissipation and noise kernel, of which is constructed the density matrix propagator of the system. We demonstrate that the Markovian approximation fails for this system. We explore the interplay between characteristic non-Markovian phenomena, such as memory effects and quantum correlations, and the quantum phenomena of superposition and entanglement.

Simulation of non-Pauli channels

Thomas Cope, Leon Hetzel, Leonardo Banchi and Stefano Pirandola

Speaker: Thomas Cope *04.10.2017, 16:30* *Poster*

We consider the simulation of a quantum channel by two parties who share a resource state and may apply local operations assisted by classical communication (LOCC). One specific type of such LOCC is standard teleportation, which is however limited to the simulation of Pauli channels. Here we show how we can easily enlarge this class by means of a minimal perturbation of the teleportation protocol, where we introduce noise in the classical communication channel between the remote parties. By adopting this noisy protocol, we provide a necessary condition for simulating a non-Pauli channel. In particular, we characterize the set of channels that are generated assuming the Choi matrix of an amplitude damping channel as a resource state. Within this set, we identify a class of Pauli-damping channels for which we bound the two-way quantum and private capacities.

Quantum correlations in an optomechanical cavity with a periodic modulation

Vahid Ameri and Mohammad Eghbali-Arrani

Speaker: Vahid Ameri 04.10.2017, 16:30 Poster

Proposing an optomechanical cavity with two mirrors where one of them is periodically modulated, we discuss the effect of periodic modulation on the quantum correlations between mirrors and between cavity field and mirrors. We find a synchronization of the periodic modulation between mirrors and also some interesting connections between the synchronization and quantum correlations of mirrors.

Optical trapping of nano-particles with a deep parabolic mirror

Vsevolod Salakhutdinov, Markus Sondermann, Luigi Carbone, Elisabeth Giacobino, Alberto Bramati and Gerhard Leuchs

Speaker: Vsevolod Salakhutdinov 04.10.2017, 16:30 Poster

We demonstrate the optical levitation of nano-particles in the focus of a dipole mode [1]. The linear-dipole mode is generated by focusing a radially polarized, so called ‘doughnut’-mode with a deep parabolic mirror that covers 94% of radiation pattern of a linear dipole.

In the experiment, CdSe/CdS dot-in-rod nano-particles were trapped. We analyze the emission of the trapped particles in terms of second-order intensity correlation functions and test the dependence of the strength of the observed anti-bunching on the number of trapped particles.

We also discuss the characteristics of the trapping potential and provide a comparison between theoretical estimations and measured trap parameters.

[1] V.Salakhutdinov et al., Optica 3(11), 1181(2016)

Improved quantum advantage with shallow circuits via non-local games

Zachary Webb

Speaker: Zachary Webb *04.10.2017, 16:30* *Poster*

A recent result by Bravyi, Gosset, and Koenig gave an explicit example of a relational problem solvable by a constant depth quantum circuit, but that any classical circuit that succeeded with probability above 3/4 required logarithmic depth. In this paper, we modify their problem slightly, and show that this new problem is still solvable with a constant depth quantum circuit, but that any classical circuit that solves the problem with larger than superpolynomially small probability requires logarithmic depth. The proof proceeds by constructing a strategy for the repeated Mermin magic square game from the classical circuit, and using known results that such a strategy cannot exist.

Artificial subsystems in multilevel single-part systems and new informaion-entropic inequalities for Clebsch-Gordan coefficients

Zhanat Seilov and Vladimir Manko

Speaker: Zhanat Seilov *04.10.2017, 16:30* *Poster*

Correlations in quantum system play essential role in quantum communication and quantum computation. Recently the notion of hidden quantum correlations was introduced. These correlations are defined for indivisible N-level quantum system (qudit) can be expressed as entropic inequalities analogous to the properties of composite quantum systems, such as subadditivity condition and strong subadditivity condition.

In our work using constructed bijective map between integers y = 1,..., N and set of variables x1,x2, ⋯ ,xn we obtain the partition of indivisible N-level system into n subsystems. Such approach allows employing the properties of composite system (bipartite, tripartite) of n subsystems to any indivisible N-level quantum system. This approach can be employed to any partition of multilevel system into "artificial" subsystems.

Using obtained functions detecting the hidden correlations in the system, we found new inequalities for special functions that determine the matrix elements of the SU(2)-group irreducible representation and the Clebsch-Gordan (C-G) coefficients for quantum angular momentum. In this approach we used representation of squares of C-G coefficients as probabilities.

Reduction of many-body terms for quantum computations with fermions

P. Kl. Barkoutsos, N. Moll, P. W. J. Staar, A. Fuhrer, S. Filipp, M. Troyer and I. Tavernelli

Speaker: Panagiotis Barkoutsos 03.10.2017, 16:30 Poster

Quantum computing is a very promising new computer paradigm with direct applications in computational sciences and simulations. In the future quantum computers may be able to simulate electronic systems with many-body fermionic systems. The direct analog implementation of such systems suffers, however, from the existence of experimentally unfeasible *k*-local terms, introduced by the encoding of the fermions into a spin system via the Jordan-Wigner transformation. In order to physically realize these terms, principles of perturbation theory may be exploited, to map the physical *k*-local interactions to a higher dimension system consisted of only *2*-local interactions. These techniques are known as Perturbative Hamiltonian Gadgets (PHGs). In order to increase the Hilbert space one or more auxiliary qubits (ancillas) are introduced, creating two distinct subspaces (physical and ancilla) in the final enlarged system. The energy difference between these two subspaces needs to be large enough so that the mixing between the states is negligible and the properties of the physical system are fully preserved. This approach gives rise to Hamiltonians consisting of coupling terms of different orders of magnitude (ranging from 1 to 10^8), making the implementation in an experimental set up very difficult. In this work we present a new approach that exploits the numerical optimization schemes to reduce *k*-local terms. We have developed a scheme to compare the eigenstates of the enlarged system to the ones of the physical system and to optimize the coupling parameters. Applying this scheme, we find a reduction of the range of coupling parameters by 6 orders of magnitude (final set of parameters varies from 1 to 10^2). This technique is scalable to multi-qubit systems and it makes the implementation of many-body terms feasible because of the reduced coupling range.

Abstracts 06.10.2017

Perfect Sampling for Quantum Gibbs States

Daniel Stilck França

Speaker: Daniel Stilck França *06.10.2017, 13:00* *Talk*

We show how to obtain perfect samples from a quantum Gibbs state on a quantum computer. To do so, we adapt one of the "Coupling from the Past"- algorithms proposed by Propp and Wilson. The algorithm has a probabilistic run-time and produces perfect samples without any previous knowledge of the mixing time of a quantum Markov chain. To implement it, we assume we are able to perform the phase estimation algorithm for the underlying Hamiltonian and implement a quantum Markov chain that satisfies certain conditions, implied e.g. by detailed balance, and is primitive. We analyse the expected run-time of the algorithm, which is linear in the mixing time and quadratic in the dimension. We also analyse the circuit depth necessary to implement it, which is proportional to the sum of the depth necessary to implement one step of the quantum Markov chain and one phase estimation. This algorithm is stable under noise in the implementation of different steps.

Energetic instability of passive states in thermodynamics

Carlo Sparaciari, David Jennings and Jonathan Oppenheim

Speaker: Carlo Sparaciari *06.10.2017, 13:15* *Talk*

Passivity is a fundamental concept in thermodynamics that demands a quantum system’s energy cannot be lowered by any reversible, unitary process acting on the system. In the limit of many such systems, passivity leads in turn to the concept of complete passivity, thermal states, and the emergence of a thermodynamic temperature. Here we only consider a single system and show that every passive state except the thermal state is unstable under a weaker form of reversibility. Indeed, we show that given a single copy of any a thermal quantum state, an optimal amount of energy can be extracted from it when we utilise a machine that operates in a reversible cycle. This means that for individual systems the only form of passivity that is stable under general reversible processes is complete passivity, and thus provides a physically motivated identification of thermal states when we are not operating in the thermodynamic limit.

Phase Transition in Chaotic Dynamics of Purification Protocol

Martin Malachov, Igor Jex and Tamás Kiss

Speaker: Martin Malachov *06.10.2017, 13:30* *Talk*

Quantum information boom in recent decades has led to new algorithms defeating classical computation in some tasks or bringing brand new possibilities. One of proposed protocol introduces measurement-based selection and modification to implement nonlinear evolution. This evolution has been proven to exhibit chaotic features in a particular set of states - pure states.

We use the dimension of fractal structure in parameter space to characterise the chaotic dynamics. We show that this chaos is not lost when the pure states are disturbed. Furthermore, while the purity serves as a control parameter the fractal dimension enjoys a phase transition - the fractal structure is resistant to disturbations (its dimension remains constant) unless passing the transition points. We also present arguments that the attractor areas explode/collapse exponentially.

Beating the Limits in Qubit Reset with Initial Correlations

Daniel Basilewitsch, Rebecca Schmidt, Dominique Sugny, Sabrina Maniscalco and Christiane P. Koch

Speaker: Daniel Basilewitsch *06.10.2017, 13:45* *Talk*

Fast and reliable reset of a qubit is a key prerequisite for any quantum technology. For real world open quantum systems undergoing non-Markovian dynamics, reset implies not only purification, but in particular erasure of initial correlations between qubit and environment. Here, we derive optimal reset protocols using a combination of geometric and numerical control theory. For factorizing initial states, we find a lower limit for the entropy reduction of the qubit as well as a speed limit. The time-optimal solution is determined by the maximum coupling strength. Initial correlations, remarkably, allow for faster reset and smaller errors. Entanglement is not necessary.

Autonomous quantum clocks: how thermodynamics limits our ability to measure time

Paul Erker, Mark Mitchison, Ralph Silva, Mischa Woods, Nicolas Brunner and Marcus Huber

Speaker: Paul Erker *06.10.2017, 14:00* *Talk*

Time remains one of the least well understood concepts in physics, most notably in quantum mechanics. A central goal is to find the fundamental limits of measuring time. One of the main obstacles is the fact that time is not an observable and thus has to be measured indirectly. Here we explore these questions by introducing a model of time measurements that is complete and self-contained. Specifically, our autonomous quantum clock consists of a system out of equilibrium --- a prerequisite for any system to function as a clock --- powered by minimal resources, namely two thermal baths at different temperatures. Through a detailed analysis of this specific clock model, we find that the laws of thermodynamics dictate a trade-off between the amount of dissipated heat and the clock's performance in terms of its accuracy and resolution. Our results furthermore imply that a fundamental entropy production is associated with the operation of *any* autonomous quantum clock, assuming that quantum machines cannot achieve perfect efficiency at finite power. More generally, autonomous clocks provide a natural framework for the exploration of fundamental questions about time in quantum theory and beyond.

State transfer in a one-dimensional strongly-interacting gas

Artem Volosniev

Speaker: Artem Volosniev *06.10.2017, 14:15* *Talk*

We study the possibility to achieve perfect state transfer in a one-dimensional gas of strongly-interacting cold atoms. First, we show that these systems give one the opportunity to engineer Heisenberg Hamiltonians with tunable spin-spin interactions. Therefore one can design chains that enjoy perfect state transfer. We illustrate this statement by analyzing dynamics in a simple yet non-trivial four-body system.

A. Volosniev et al, Phys. Rev. A 91, 023620 (2015); O. Marchukov et al, Nature Communications 7, 13070 (2016)

Precision arrangement of phosphorus atoms on Si(100) through chlorine mask

Tatiana Pavlova, Vladimir Shevlyuga, Boris Andryushechkin, George Zhidomirov and Konstantin Eltsov

Speaker: Tatiana Pavlova *06.10.2017, 14:45* *Talk*

Realization of the silicon quantum computer on nuclear spins 31P:28Si requires the placement of phosphorus atoms (qubits) with very high accuracy. The most accurate method for donor-based silicon devices is the scanning tunneling microscopy (STM) lithography which allows to place P atoms with precision ~10Å. This spatial limitation is related to a need to have three clean Si dimers for the phosphine dissociation on the Si(100)-2x1-H surface. We propose a method for P incorporation into the upper Si(100) layer with atomic precision on the place of the selected Si atom. The mask on the Si(100) surface is formed by the chlorine monolayer and then it is patterned with the STM-tip to create Si vacancy. To investigate the phosphine adsorption on the Si(001)-2x1-Cl surface with vacancies in the adsorbate layer and combined vacancies with removal of silicon atoms, we performed DFT calculations. As a starting point of our method realization, we prepared Si(100)-2x1-Cl surface with a low defect density. A STM tip is used to desorb Cl with Si atoms. Observed STM images were compared to simulated images that helps to identify the type of the created defects. This work was supported by Grant No.16-12-00050 from the Russian Science Foundation.

Ultimate limits for quantum magnetometry via time-continuous measurements

Francesco Albarelli, Matteo A. C. Rossi, Matteo G. A. Paris and Marco G. Genoni

Speaker: Francesco Albarelli *06.10.2017, 15:00* *Talk*

We address the estimation of the magnetic field B acting on an ensemble of atoms with total spin J subjected to collective transverse noise. By preparing an initial spin coherent state, for any measurement performed after the evolution, the mean-square error of the estimate is known to scale as 1/J, i.e. no quantum enhancement is obtained. Here, we consider the possibility of continuously monitoring the atomic environment, and conclusively show that strategies based on time-continuous non-demolition measurements followed by a final strong measurement may achieve Heisenberg-limited scaling 1/J 2 and also a quantum-enhanced scaling in terms of the interrogation time. We also find that time-continuous schemes are robust against detection losses, as we prove that the quantum enhancement can be recovered also for finite measurement efficiency. Finally, we analytically prove the optimality of our strategy.

High resolution sensing of high-frequency fields with continuous dynamical decoupling

Alexander Stark, Nati Aharon, Thomas Unden, Daniel Louzon, Alexander Huck, Alex Retzker, Ulrik Lund Andersen and Fedor Jelezko

Speaker: Nati Aharon 06.10.2017, 15:15 Talk

Dynamical decoupling is the method of choice for sensing weak oscillating signals. However, due to the required pulsing rate, state of the art decoupling sequences are limited to detect signals in the kHz to MHz frequency range. Sensing of higher frequencies is possible with relaxometry measurements, where the bandwidth is limited by the pure dephasing time of the probe system. We present a general scheme that relaxes this limitation and allows for the enhanced detection of high frequency signals with a coherence time limited sensitivity. By the application of continuous driving fields robustness to both external and controller noise is achieved in such a way that the signal induces rotations of the robust qubit. This results in a significantly enhanced coherence time and enables high resolution sensing. While our scheme is general and suitable to a variety of atomic and solid-state systems, we experimentally demonstrated it with the Nitrogen Vacancy center in diamond, utilizing its ground sub-states as a qubit. With coherence times of up to 1.43 milliseconds we performed high-frequency sensing with a sub-kHz resolution, reaching a smallest detectable magnetic field strength of 4 nT at 1.6 GHz.

Nonlocal bunching of composite bosons

Zakarya Lasmar, Dagomir Kaszlikowski and Pawel Kurzynski

Speaker: Zakarya Lasmar 06.10.2017, 15:30 Talk

It was suggested that two entangled fermions can behave like a single boson and that the bosonic quality is proportional to the degree of entanglement between the two particles. The relation between bosonic quality and entanglement is quite natural if one takes into account the fact that entanglement appears in bound states of interacting systems. However, entanglement can still be present in spatially separated subsystems that do not interact anymore. These systems are often a subject of studies on quantum nonlocality and foundations of quantum physics. Here, we ask whether an entangled spatially separated fermionic pair can exhibit bosonic properties. We show that in certain conditions the answer to this question can be positive. In particular, we propose a nonlocal bunching scenario in which two such pairs form an analogue of a two-partite bosonic Fock state.

Simultaneous estimation of conjugate parameters: Reaching the Cramér-Rao bound with coherent states

Matthieu Arnhem, Evgueni Karpov and Nicolas Cerf

Speaker: Matthieu Arnhem *06.10.2017, 15:45* *Talk*

We prove the optimality of a measurement scheme two phase conjugated input states introduced by N. J. Cerf and S. Iblisdir in 2001. We propose an extended and implementable measurement scheme which measures simultaneously n parameters encoded in the quadratures of n input coherent states.

List of authors

Name	*Affiliation*
Scott, Aaronson	University of Texas at Austin
Nicolas, Abt	Universität Stuttgart
Antonio, Acin	ICFO - The Institute of Photonic Sciences
Satyabrata, Adhikari	Deptartment of Mathematics, BIT Mesra, Ranchi-835215, India
Mikael, Afzelius	Université de Genève
Girish S., Agarwal	Texas A&M University, College Station, Texas 77843, USA; Oklahoma State University, Stillwater, Oklahoma 74078, USA
Costantino, Agnesi	Dipartimento di Ingegneria dell'Informazione, Universita degli Studi di Padova
Pankaj, Agrawal	Institute of Physics, Bhubaneswar
Nati, Aharon	The Hebrew University of Jerusalem
Francesco, Albarelli	Università degli Studi di Milano
Gernot, Alber	Technische Universität Darmstadt
Javier Alejandro Lopez, Alfaro	UNAM-ICN
Maria, Amanti	Paris Diderot University
Vahid, Ameri	University of Hormozgan
Charis, Anastopoulos	University of Patras
Ulrik Lund, Andersen	Technical University of Denmark
Boris, Andryushechkin	Prokhorov General Physics Institute, Russian Academy of Sciences
Ali, Angulo	UNAM-ICN
Matthieu, Arnhem	Université Libre de Bruxelles
Arvind, Arvind	Indian Institute of Science Education and Research, Mohali, India
Valentin, Averchenko	Max-Planck-Institut für die Physik des Lichts
Florent, Baboux	Paris Diderot University
Flavio, Baccari	ICFO
Jean-Daniel, Bancal	Quantum optics theory group, University of Basel

Jean-Daniel, Bancal	GAP-Optique, Université de Genève
Leonardo, Banchi	University College London
Shimshon, Bar-Ad	Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University
Panagiotis, Barkoutsos	IBM Research GmbH, Zurich Research Laboratory
Jorge, Barreto	The University of Bristol
Daniel, Basilewitsch	Theoretical Physics, University of Kassel
Ömer, Bayraktar	Max Planck Institute for the science of light
Nimrod, Benshalom	Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University
Ville, Bergholm	ISI Foundation
Daniel, Bhatti	Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen, Germany; Erlangen Graduate School in Advanced Optical Technologies (SAOT), 91052 Erlangen, Germany
Giuseppe, Bianco	Matera Laser Ranging Observatory, Agenzia Spaziale Italiana
Sven, Bodenstedt	Universität Stuttgart
Jonatan, Bohr Brask	University of Geneva
Boris, Bourdoncle	ICFO - The Institute of Photonic Sciences
Kamil, Bradler	University of Ottawa
Alberto, Bramati	Laboratoire Kastler Brossel, UPMC-Sorbonne Universités, CNRS, ENS-PSL, Research University, Collège de France
Samuel, Braunstein	Department of Computer Science, University of York
Paul, Brookes	UCL
Michel, Brune	Laboratoire Kastler-Brossel
Nicolas, Brunner	University of Geneva
Félix, Bussières	Université de Genève
Yu, Cai	Center for Quantum Technologies
Luca, Calderaro	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Tigrane, Cantat-Moltrecht	Laboratoire Kastler-Brossel
Valentina, Caprara Vivoli	QuTech, TU Delft

Luigi, Carbone	CNR NANOTEC-Istituto di Nanotecnologia
Daniel, Cavalcanti	ICFO The Institute of Photonic Sciences
Nicolas, Cerf	QuIC, Université Libre de Bruxelles
Indranil, Chakrabarty	International Institute of Information Technology, Hyderabad
Areeya, Chantasri	Centre for Quantum Dynamics, Griffith University
Sourav, Chatterjee	Max Planck Institute for the Science of Light
Anubhav, Chaturvedi	Krajowe Centrum Informatyki Kwantowej
Chen-Fu, Chiang	State University of New York Polytechnic Institute
Yue-Sum, Chin	Centre for Quantum Technologies, National University of Singapore
Aurélien, Chopinaud	Laboratoire Aimé Cotton (CNRS, UPSUD, ENS PSACLAY)
Sujit, Choudhary	Institute of Physics, Bhubaneswar
Alexandru, Cojocaru	School of Informatics, University of Edinburgh
Wan, Cong	National University of Singapore
Tim, Coopmans	TU Delft
Thomas, Cope	University of York
Raul, Corrêa	Universidade Federal de Minas Gerais
Jean, Cortés-Vega	Universidad de Concepción
Rodrigo, Cortiñas	Laboratoire Kastler-Brossel
Hector, Cruz Ramírez	UNAM-ICN
Axel, Dahlberg	QuTech, TU Delft
Marcus, Dahlem	Masdar Institute, Khalifa University of Science and Technology
Durga, Dasari	Universität Stuttgart
Chandan, Datta	Institute of Physics, Bhubaneswar
David, Davtyan	University of Amsterdam
Julio, de Vicente	Universidad Carlos III de Madrid
Tommaso, Demarie	Singapore University of Technology and Design (SUTD)
Amit, Devra	Indian Institute of Science Education and Research, Mohali, India

Daniele, Dequal	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Himadri, Dhar	Vienna University of Technology (TU WIEN)
Carlo, Di Franco	Nanyang Technological University
Sara, Di Martino	Universitat Autònoma de Barcelona-UAB
Andrew C., Doherty	University of Sydney
Florian, Dolde	Nanotechnologies Inc.
Kavita, Dorai	Indian Institute of Science Education and Research, Mohali, India
Sara, Ducci	Paris Diderot University
Inês, Dutra	CRACS INESC TEC and Faculty of Science, University of Porto
Jan, Dziewior	Max-Planck-Institute for Quantum Optics
Jonathan, Efroni	Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University
Mohammad, Eghbali-Arani	University of Kashan
Fadi, El Hallak	Seagate Technology
Hany, Elemy	Aalto University, School of Electrical Engineering, Department of Communications and Networking
David, Elkouss	QuTech, TU Delft
Dominique, Elser	Max Planck Institute for the science of light
Konstantin, Eltsov	Prokhorov General Physics Institute, Russian Academy of Sciences
Paul, Erker	Universita della Svizzera italiana, Universitat Autonoma de Barcelona
Chris, Erven	The University of Bristol
Mark J., Everiit	Loughborough University
Paolo, Facchi	Università degli Studi di Bari "A. Moro"
Alessandro, Ferraro	Queen's University Belfast
Radim, Filip	Palacky University Olomouc
S., Filipp	IBM Research GmbH, Zurich Research Laboratory
Amit, Finkler	3. Physikalisches Institut, Universität Stuttgart, Germany

Joseph, Fitzsimons	Singapore University of Technology and Design
Helmut, Frasch	3. Physikalisches Institut, Universität Stuttgart, Germany
Florian, Fröwis	Université de Genève
A., Fuhrer	IBM Research GmbH, Zurich Research Laboratory
Demitry, Farfurnik	Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University
Mariami, Gachechiladze	Universität Siegen
Fei, Gao	Beijing University of Posts and Telecommunications
Giancarlo, Garnero	Università degli Studi di Bari "A. Moro"
Marwa, Garsi	3. Physikalisches Institut, Universität Stuttgart
Marco G., Genoni	Università degli Studi di Milano
Alexandru, Gheorghiu	University of Edinburgh, School of Informatics
Elisabeth, Giacobino	Laboratoire Kastler Brossel, UPMC-Sorbonne Universités, CNRS, ENS-PSL, Research University, Collège de France
Nicolas, Gisin	Université de Genève
Kenneth, Goodenough	QuTech, TU Delft
Dardo, Goyeneche	Jagiellonian University (Cracow) & University of Gdansk (Gdansk)
Peter, Greulich	Tesat-Spacecom GmbH & Co. KG
Ivonne, Guevara	Centre for Quantum Dynamics, Griffith University
Otfried, Gühne	Universität Siegen
Mariia, Gumberidze	Palacky University Olomouc
Kevin, Günthner	Max Planck Institute for the science of light
Guang-Can, Guo	University of Science and Technology of China
Corentin, Gut	Université de Genève
Björn, Gütlich	Deutsche Zentrum für Luft- und Raumfahrt e. V. (DLR)
Geraldine, Haack	University of Geneva
Thorsten, Haase	Technische Universität Darmstadt
Sina, Hamedani Raja	University of Turku

Ronald, Hanson	QuTech, TU Delft
Serge, Haroche	Laboratoire Kastler-Brossel
Martin, Hebenstreit	Institute for Theoretical Physics, University of Innsbruck
Frank, Heine	Tesat-Spacecom GmbH & Co. KG
Jonas, Helsen	QuTech- TUDelft
Leon, Hetzel	Universität Bremen
Karl, Horn	Universität Kassel
Karol, Horodecki	Institute of Informatics, National Quantum Information Centre, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Poland
Michał, Horodecki	Univeristy of Gdansk
Oussama, Houhou	Queen's University Belfast
Chang-Yu, Hsieh	Singapore-MIT Alliance for Research and Technology (SMART) Centre
Marcus, Huber	IQOQI Vienna
Alexander, Huck	Technical University of Denmark
Peter C., Humphreys	QuTech, TU Delft
Marion, Jacquey	Laboratoire Aimé Cotton (CNRS, UPSUD, ENS PSACLAY)
Ingmar, Jakobi	Universität Stuttgart
Fedor, Jelezko	Ulm University
David, Jennings	University of Oxford
Stefan, Jesenski	Universität Stuttgart
Igor, Jex	Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
Gerard, Jiménez Machado	ICFO- Institut de Ciències Fotòniques
Niklas, Johansson	Institutionen för systemteknik, Linköpings Universitet
Jaewoo, Joo	University of Leeds
Florian, Kaiser	Universität Stuttgart
Norbert, Kalb	QuTech, TU Delft
Michał, Kamoń	Gdańsk University of Technology

Jedrzej, Kaniewski	QMATH (University of Copenhagen)
Marcin, Karczewski	Adam Mickiewicz University in Poznań
Goktug, Karpat	Izmir University of Economics
Evgueni, Karpov	Université Libre de Bruxelles
Elham, Kashefi	School of Informatics - University of Edinburgh
Dagomir, Kaszlikowski	National University of Singapore
Joris, Kattemölle	University of Amsterdam / QuSoft
Kamil, Khadiev	University of Latvia, Kazan Federal University
Aliya, Khadieva	Kazan Federal University
Imran, Khan	Max Planck Institute for the science of light
Tamás, Kiss	Wigner Research Centre for Physics, Hungarian Academy of Sciences
Nico, Klein	Physics Faculty, University of Munich
Lukas, Knips	Physics Faculty, University of Munich
Christiane, Koch	Universität Kassel
Michal, Kolář	Palacky University Olomouc
Theodora, Kolioni	UNIVERSITY OF PATRAS
Philipp, Konzelmann	Universität Stuttgart
Jarosław, Korbicz	Gdansk University of Technology/KCIK
Olena, Kovalenko	Palacky University, Olomouc
Barbara, Kraus	University of Innsbruck
Christian, Kurtsiefer	Centre for Quantum Technologies, National University of Singapore
Pawel, Kurzynski	Adam Mickiewicz University in Poznań & National University of Singapore
Elsi-Mari, Laine	University of Turku
Aniello, Lampo	ICFO
Jan-Åke, Larsson	Linköping University
Zakarya, Lasmar	Adam Mickiewicz University in Poznań
Riccardo, Laurenza	University of York
Jonathan, Lavoie	Université de Genève
, Le Phuc Thinh	QuTech - TU Delft
Aristide, Lemaitre	C2N

Gerd, Leuchs	Max Planck Institute for the Science of Light
Maciej, Lewenstein	ICFO/ICREA
Chuan-Feng, Li	University of Science and Technology of China
Yeong-Cherng, Liang	Department of Physics, National Cheng Kung University
Pei-Sheng, Lin	Department of Physics, National Cheng Kung University
Noah, Linden	University of Bristol
Victoria, Lipinska	QuTech - TU Delft
Julio, Lopez	UNAM
Daniel, Louzon	The Hebrew University of Jerusalem
Vincenza, Luceri	e-GEOS S.p.A., Matera (Italy)
Kummo, Luoma	Institut für Theoretische Physik, Technische Universität Dresden
Martin, Malachov	Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague
Giorgio, Maltese	Paris Diderot University
Sabrina, Maniscalco	University of Turku
Vladimir, Manko	P.N. Lebedev Physical Institute, Moscow, Russia
Ilnaz, Mannapov	Kazan Federal University
Atul, Mantri	Singapore University of Technology and Design
Davide, Marangon	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Christoph, Marquardt	Max Planck Institute for the science of light
Ugo, Marzolino	Ruder Boskovic Institute
Nicolas, Menicucci	School of Science, RMIT University, Melbourne, Victoria 3001, Australia
Nina, Megier	Institut für Theoretische Physik, Technische Universität Dresden
Patrick W., Mills	Loughborough Univeristy
Utkarsh, Mishra	Asia Pacific Center for Theoretical Physics, South Korea
Mark, Mitchison	Ulm University
Debasis, Mondal	Centre for Quantum Technologies

Ashley, Montanaro	University of Bristol
Darren W, Moore	Queen's University Belfast
Dimitris, Moustos	University of Patras
N., Moll	IBM Research GmbH, Zurich Research Laboratory
Christian, Müller	Max Planck Institute for the science of light
Glaucia, Murta	QuTech, Delft University of Technology
Nikolajs, Nahimovs	University of Latvia
Philipp, Neumann	Universität Stuttgart
Thanh-Long, Nguyen	ETH Zürich
Thomas, Oeckinghaus	3. Physikalisches Institut, Universität Stuttgart, Germany
Steffen, Oppel	Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen, Germany
Jonathan, Oppenheim	University College London
Carlo, Ottaviani	University of York
Sam, Pallister	University of Bristol
Panagiotis, Papanastasiou	University of York
Matteo G. A., Paris	Università degli Studi di Milano
Ryan, Parker	University of York
Anirban, Pathak	Jaypee Institute of Information Technology
Arun Kumar, Pati	Harish-Chandra Research Institute, Allahabad, India
Sabrina, Patsch	Universität Kassel
Tatiana, Pavlova	Prokhorov General Physics Institute, Russian Academy of Sciences
Rojiar, Penjweini	Max Planck Institute for the Science of Light
Juan, Pérez Torres	ICFO- Institut de Ciències Fotòniques
Sabine, Philipp-May	Deutsche Zentrum für Luft- und Raumfahrt e. V. (DLR)
Jyrki, Piilo	University of Turku
Stefano, Pirandola	University of York
Marc-Oliver, Pleinert	Friedrich-Alexander-Universität Erlangen-Nürnberg

R., Prabhu	Indian Institute of Technology, Patna, India
Prithviraj, Prabhu	SSN College of Engineering, Chennai, Tamil Nadu, India
Laurence, Pruvost	Laboratoire Aimé Cotton (CNRS, UPSUD, ENS PSACLAY)
Jean-Michel, Raimond	Laboratoire Kastler-Brossel
Zahra, Raissi	ICFO
Debraj, Rakshit	Institute of Physics, Polish Academy of Sciences, Warsaw,Poland
Patrick, Rall	University of Texas at Austin
Brice, Ravon	Laboratoire Kastler-Brossel
Maharshi, Ray	CQT, National University of Singapore
Mohsen, Razavi	University of Leeds
Andreas, Reiserer	Max Planck Institute of Quantum Optics
Torsten, Rendler	Universität Stuttgart
Alex, Retzker	The Hebrew University of Jerusalem
Jonas, Reuter	Bethe Center for Theoretical Physics, Universität Bonn
Jérémy, Ribeiro	TU Deflt
Marco, Rivera-Tapia	Universidad de Concepción
Denis, Rosset	Department of Physics, National Cheng Kung University
Matteo A. C., Rossi	Università degli Studi di Milano
Filip, Rozpedek	QuTech, TU Delft
Russell P., Rundle	Loughborough University
Omer, Sakarya	Institute of Informatics, National Quantum Information Centre, Faculty of Mathematics, Physics and Informatics, University of Gdańsk, Poland
Vsevolod, Salakhutdinov	Max Planck Institute for the Science of Light
Alexia, Salavrakos	ICFO - The Institute of Photonic Sciences
Luis José, Salazar Serrano	ICFO- Institut de Ciències Fotòniques
Pablo L., Saldanha	Universidade Federal de Minas Gerais
Sasha, Sami	International Institute of Information Technology, Hyderabad

John H., Samson	Loughborough University
Anna, Sanpera	Universitat Autònoma de Barcelona
Raqueline, Santos	University of Latvia
Karen, Saucke	Tesat-Spacecom GmbH & Co. KG
David, Sauerwein	University of Innsbruck
Gaurav, Saxena	Indian Institute of Science Education and Research (IISER) Mohali
Clément, Sayrin	Laboratoire Kastler-Brossel
Sheikh, Sazim	Harish-Chandra Research Institute, Allahabad, India
Valerio, Scarani	Centre for quantum technologies and National University of Singapore
Christian, Schaffner	QuSoft, University of Amsterdam
Philipp, Scheiger	3. Physikalisches Institut, Universität Stuttgart, Germany
Matteo, Schiavon	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Thomas, Schiet	QuTech, TU Delft
Rebecca, Schmidt	Turku Centre for Quantum Physics, Department of Physics and Astronomy, University of Turku
Thomas, Schulte-Herbrüggen	TU München
Gerhard, Schunk	Max-Planck-Institut für die Physik des Lichts
Christian, Schwemmer	Physics Faculty, University of Munich
Stefan, Seel	Tesat-Spacecom GmbH & Co. KG
Zhanat, Seilov	Moscow Institute of Physics and Technology
Henry, Semenenko	The University of Bristol
Katharina, Senkalla	Max-Planck-Institute for Quantum Optics
Lluc, Sendra Molins	ICFO- Institut de Ciències Fotòniques
Golnoush, Shafiee	Max Planck Institute for the Science of Light
Jiangwei, Shang	Universität Siegen
Chandan, Sharma	Indian Institute of Science Education and Research (IISER) Mohali
Vladimir, Shevlyuga	Prokhorov General Physics Institute, Russian Academy of Sciences
Philip, Sibson	The University of Bristol

Ralph, Silva	University of Geneva
Carla, Silva	Faculty of Science, University of Porto
Amandeep, Singh	Indian Institute of Science Education and Research Mohali
Harpreet, Singh	Indian Institute of Science Education and Research, Mohali, India
Giulia, Sinnl	Paris Diderot University
George, Siopsis	University of Tennessee
Paul, Skrzypczyk	University of Bristol
Markus, Sondermann	Max Planck Institute for the Science of Light
Carlo, Sparaciari	University College London
Cornelia, Spee	University of Siegen
Timothy, Spiller	University of York
Ana Cristina, Sprotte Costa	University of Siegen
Alexander, Stark	Technical University of Denmark
P. W.J., Staar	IBM Research GmbH, Zurich Research Laboratory
Andrea, Stanco	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Matthias, Steiner	Centre for Quantum Technologies, National University of Singapore
Mark, Steudtner	QuTech- TUDelft
Daniel, Stilck França	Technische Universität München
Birgit, Stiller	Max Planck Institute for the science of light
Rainer, Stoehr	3. Physikalisches Institut, Universität Stuttgart, Germany
Peter C., Strassmann	Université de Genève
Dominique, Sugny	Laboratoire Interdisciplinaire Carnot de Bourgogne, UMR 5209 CNRS-Université de Bourgogne Franche Comté
Ivan, Supic	ICFO The Institute of Photonic Sciences
Walter, Strunz	Institut für Theoretische Physik, Technische Universität Dresden
Denis, Sych	Lebedev Physical Institute
Armin, Tavakoli	University of Geneva

I., Tavernelli	IBM Research GmbH, Zurich Research Laboratory
Kishore, Thapliyal	Jaypee Institute of Information Technology
Le Phuc, Thinh	QuTech, TU Delft
Todd, Tilma	Tokyo Institute of Technology
Alexey, Tiranov	Université de Genève
Marco, Tomasin	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Geza, Toth	Department of Theoretical Physics, University of the Basque Country UPV/EHU, Bilbao, Spain; IKERBASQUE, Basque Foundation for Science, Bilbao, Spain; Wigner Research Centre for Physics, Hungarian Academy of Sciences, Budapest, Hungary
M., Troyer	Institute for Theoretical Physics, ETHZ
Daniel, Tröndle	Tesat-Spacecom GmbH & Co. KG
Jan, Tuziemski	Gdansk University of Technology/KCIK
Thomas, Unden	Ulm University
Roope, Uola	University of Siegen
Alfred, U'Ren	UNAM-ICN
Vladyslav C., Usenko	Palacky University, Olomouc
Lev, Vaidman	Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University
Adam, Vallés Marí	University of Witwatersrand
Giuseppe, Vallone	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Suzanne B., van Dam	QuTech, TU Delft
Francesco, Vedovato	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Menno, Veldhorst	QuTech, TU Delft
Bruno, Viaris de Lesegno	Laboratoire Aimé Cotton (CNRS, UPSUD, ENS PSACLAY
Paolo, Villoresi	Dipartimento di Ingegneria dell'Informazione, Università degli studi di Padova
Carlos, Viviescas	Departamento de Física, Universidad Nacional de Colombia

Ulrich, Vogl	Max-Planck-Institut für die Physik des Lichts
Artem, Volosniev	TU Darmstadt
Joachim, von Zanthier	Friedrich-Alexander-Universität Erlangen-Nürnberg
Hüseyin, Vural	IHFG , Uni-Stuttgart
Zachary, Webb	University of Texas at Austin
Markus, Weber	Max Planck Institute for the Science of Light
Stephanie, Wehner	QuTech, TU Delft
Harald, Weinfurter	Physics Faculty, University of Munich
Ralph, Wiegner	Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), 91058 Erlangen, Germany
Howard, Wiseman	Centre for Quantum Dynamics, Griffith University
Peter, Wittek	ICFO
Erik, Woodhead	ICFO - The Institute of Photonic Sciences
Mischa, Woods	University College London
Alex, Wozniakowski	Harvard University
Joerg, Wrachtrup	3. Physikalisches Institut, Universität Stuttgart, Germany
Jörg, Wrachtrup	3. Physikalisches Institut, Universität Stuttgart
Abel, Yuste	Universitat Autònoma de Barcelona
Sebastian, Zaiser	Universität Stuttgart
Andrea, Zappe	Universität Stuttgart
Herwig, Zech	Tesat-Spacecom GmbH & Co. KG
Yanbao, Zhang	NTT Basic Research Laboratories, NTT Corporation
George, Zhidomirov	Prokhorov General Physics Institute, Russian Academy of Sciences
Yuqian, Zhou	State Key Laboratory of Networking and Switching Technology,Beijing University of Posts and Telecommunications, Beijing
Mansur, Ziatdinov	Kazan Federal University
Florestan, Ziem	3. Physikalisches Institut, Universität Stuttgart
Karol, Zyczkowski	Jagiellonian University (Cracow) & Polish Academy of Sciences (Warsaw)