BOOK OF ABSTRACTS

15th Central European Quantum Information Processing Workshop

June 13th–June 16th 2018, Smolenice, Slovakia

http://ceqip.eu

CEQIP 2018

CEQIP 2018 (Central European Quantum Information Procesing workshop) is traditionally focused on current challenges and paradigms of mathematical and computational aspects of emerging quantum technologies. One of the strengths is the traditionally strong social program creating very friendly and creative atmosphere. Besides traditional wine tasting and a cipher game we plan to visit surrounding natural beauties.

Venue

The workshop will be held in *Smolenice Castle* which history dates back to the 15th century and currently serves as the Congress Center of Slovak Academy of Sciences. It is situated approximately 60 km northeast from Bratislava in the central area of the smallest Slovakian mountains called Malé Karpaty.

Invited speakers

- ⋆ Alessandro Bisio (Pavia)
- ⋆ Marcus Huber (Vienna)
- ⋆ Matthias Kleinmann (Siegen)
- ⋆ Robert König (Munich)
- ⋆ Sergii Strelchuk (Cambridge)
- ⋆ Tamás Vértesi (Debrecen)

Selection Comittee

- ⋆ Daniel Reitzner (chair)
- ⋆ Mário Ziman
- ⋆ Sergii Strelchuk
- ⋆ Alessandro Bisio
- ⋆ Marcus Huber
- ⋆ Matthias Kleinmann
- ⋆ Felix Leditzky
- ⋆ Jed Kaniewski
- ⋆ János Asboth

Organizing Team

- ⋆ Jan Bouda
- ⋆ Daniel Reitzner
- ⋆ Tomáš Rybár
- ⋆ Michal Sedlák
- ⋆ Angelika Winczerová
- ⋆ Martina Zemanová
- ⋆ Mário Ziman
- ⋆ Peter Rapčan
- ⋆ Libor Caha

The workshop is organized by Research Center for Quantum Information, Institute of Physics, Slovak Academy of Sciences (Bratislava) and Quantum Laboratory, Faculty of Informatics, Masaryk University (Brno).

Program

Wednesday, 13.6.2018

16:30	Arrival and registration (with refreshment)
17:30	Evening session
17:30	Matthias Kleinmann (I)
18:10	Sergey Filippov (C)
18:35	Stefan Baeuml (C)
19:00	End of session
19:00	Welcome dinner

Thursday, 14.6.2018

08:00	Breakfast
09:00	Morning session
09:00	Tamás Vértesi (I)
09:40	Andreas Bluhm (C)
10:05	Frédéric Dupuis (C)
10:30	Coffee & Refreshment
11:00	Sergii Strelchuk (I)
11:40	Daniel Nagaj (C)
12:05	Vilasini Venkatesh (C)
12:30	End of session
12:30	Lunch
14:00	Afternoon session
14:00	Marcus Huber (I)
14:40	Chris Perry (C)
15:05	Aleksandra Krawiec (C)
15:30	End of session
15:30	Coffee & Refreshment
16:00	Poster session
18:30	Cipher game registration
18:30	Dinner
19:00	Cipher game

Friday, 15.6.2018

08:00	Breakfast
09:00	Morning session
09:00	Robert König (I)
09:40	Miguel Navascues (C)
10:05	Remigiusz Augusiak (C)
10:30	Group photo
10:35	Coffee & Refreshment
11:00	Alessandro Bisio (I)
11:40	Jędrzej Kaniewski (C)
12:05	Zbigniew Puchała (C)
12:30	End of session
12:30	Lunch
13:30	Conference trip
19:30	Conference dinner

Saturday, 16.6.2018

09:00	Breakfast
09:30	Morning session
09:30	Marti Perarnau-Llobet (C)
09:55	Libor Caha (C)
10:20	Wieslaw Laskowski (C)
10:45	End of session
10:45	Take Away Refreshment
11:00	Conference bus

(I) Invited talk (35 + 5 min.)
(C) Contributed talk (20 + 5 min.)

Invited talks

1. **Alessandro Bisio:** HIGHER ORDER QUANTUM COMPUTATION

   Higher order quantum computation is an extension of quantum computation where input and output of transformations can be transformations themselves. This idea leads to the notion of higher order maps, which generalise channels and quantum operations. Such a generalisation goes recursively, with the construction of a full hierarchy of maps of increasingly higher order. The analysis of special cases already showed that higher order maps, exhibit features that cannot be tracked down to the usual circuits, such as indefinite causal structures, providing provable advantages over circuital maps. The present treatment provides a general framework where this kind of analysis can be carried out in full generality. Higher order quantum computation is introduced axiomatically with a formulation based on the language of types of transformations. Complete positivity of higher order maps is derived from the general admissibility conditions instead of being postulated as in previous approaches. The recursive characterization of convex sets of maps of a given type is used to prove equivalence relations between different types. The axioms for higher order computation do not refer to the specific mathematical structure of quantum theory, and can be therefore exported in the context of any general operational probabilistic theory.

2. **Marcus Huber:** THERMODYNAMIC LIMITATIONS TO QUANTUM MEASUREMENTS

   Projective measurements and the Born rule are centerpieces of the foundation of quantum information theory. They do, however, seem to violate the third law of thermodynamics. We show that in a self-contained description, quantum measurements are indeed strictly speaking impossible and can only be approximated at a work cost that diverges with the desired quality of the measurement approaching perfection. We then build an explicit model for a self contained measurement and show that reasonable measurements of quantum systems require macroscopic units of energy in order to be realised.

3. **Matthias Kleinmann:** METHODS FOR A CONCLUSIVE VERIFICATION OF BIPARTITE BOUND ENTANGLEMENT

   Bipartite bound entangled states form a class of states with a small volume within the quantum states. Also, this class of states is particularly difficult to prepare experimentally, because bound entangled states are both, entangled and mixed. Even if data has been taken successfully, yet another challenge is the actual verification that such a preparation was successful, since all states compatible with the data have to be verified to be bound entangled. In this talk I will present a method to find states which are most suitable for preparation and verification and I detail the statistical methods for verifying that the experimental state was indeed bound entangled.

4. **Robert König:** QUANTUM ADVANTAGE WITH SHALLOW CIRCUITS

   Joint work with Sergey Bravyi and David Gosset

   We prove that constant-depth quantum circuits are more powerful than their classical counterparts. To this end we introduce a non-oracular version of the Bernstein-Vazirani problem which we call the 2D Hidden Linear Function problem. An instance of the problem is specified by a quadratic form q that maps n-bit strings to integers modulo four. The goal is to identify a linear boolean function which describes the action of q on a certain subset of n-bit strings. We prove that any classical probabilistic circuit composed of bounded fan-in gates that solves the 2D Hidden Linear Function problem with high probability must have depth logarithmic in n. In contrast, we show that this problem can be solved with certainty by a constant-depth quantum circuit composed of one- and two-qubit gates acting locally on a two-dimensional grid.

5. **Sergii Strelchuk:** LEARNING HARD QUANTUM DISTRIBUTIONS WITH VARIATIONAL AUTOENCODERS

   Studying general quantum many-body systems is one of the major challenges in modern physics because it requires computational resources that scale exponentially with the size of the system. Simulating the evolution of a state, or even storing its description, rapidly becomes intractable for exact classical algorithms. Recently, machine learning techniques, in the form of restricted Boltzmann machines, have been proposed as a way to efficiently represent certain quantum states with applications in state tomography and ground state estimation. In my talk, I will introduce a new representation of states based on variational autoencoders. Variational autoencoders are a type of generative model in the form of a neural network. We probe the power of this representation by encoding probability distributions associated with states from different classes.

   We focus on two questions: (i) Are deeper networks better at learning quantum states? (ii) How well can we learn "hard" states?

   I will review recent mathematical results which explore how depth improves the representational capability of networks for classical problems and discuss our results for the quantum case.

6. **Tamás Vértesi:** USEFUL CORRELATIONS FROM BOUND ENTANGLED STATES

   Bound entangled states are very weakly entangled states. In fact they are so weakly entangled that given an infinite number of copies, no pure state entanglement can be distilled from them. Nevertheless, they are useful in certain applications such as quantum key distribution. Here we show that bipartite bound entangled states are also useful in metrology and Bell nonlocality. In particular they can outperform separable states in linear interferometers and can give rise to Bell inequality violation.

Contributed talks

1. **Remigiusz Augusiak:** BELL INEQUALITIES FOR MAXIMALLY ENTANGLED STATES
   Joint work with Alexia Salavrakos, Jordi Tura, and Peter Wittek

   Bell inequalities have traditionally been used to demonstrate that quantum theory is nonlocal, in the sense that there exist correlations generated from composite quantum states that cannot be explained by means of local hidden variables. With the advent of device-independent quantum information protocols, Bell inequalities have gained an additional role as certificates of relevant quantum properties. In this work, we consider the problem of designing Bell inequalities that are tailored to detect maximally entangled states. We introduce a class of Bell inequalities valid for an arbitrary number of measurements and results, derive analytically their tight classical, nonsignaling, and quantum bounds and prove that the latter is attained by maximally entangled states. Our inequalities can therefore find an application in deviceindependent protocols requiring maximally entangled states.

2. **Stefan Baeuml:** FUNDAMENTAL LIMITATIONS ON THE CAPACITIES OF BIPARTITE QUANTUM INTERACTIONS
   Joint work with Siddhartha Das and Mark M. Wilde

   Bipartite quantum interactions have applications in a number of different areas of quantum physics, reaching from fundamental areas to modern applications such as quantum computers, QKD and other protocols. A particular aspect of the study of bipartite interactions is concerned with the entanglement that can be created in such interactions. Here we present our work on two basic building blocks of bipartite quantum protocols, the generation of entanglement and secret key via bipartite quantum interactions. In particular, we provide a non-trivial, efficiently computable upper bound on the PPT-assisted quantum capacity of bidirectional quantum channels. In addition, we provide an upper bound on the private capacity of bidirectional quantum channels assisted by LOCC. As an application, we introduce a cryptographic protocol, which we call private reading of a classical digital memory.

3. **Andreas Bluhm:** QUANTUM COMPRESSION RELATIVE TO A SET OF MEASUREMENTS
   Joint work with Lukas Rauber and Michael M. Wolf

   We investigate the possibility of compressing a quantum system to one of smaller dimension in a way that preserves the measurement statistics of a given set of observables. Here, we allow for an arbitrary amount of classical side information. We find that the latter can be bounded, which implies that the minimal compression dimension is stable. Various bounds on the minimal compression dimension are proven and an SDP-based algorithm for its computation is provided. The results are based on two independent approaches: an operator algebraic method using a fixed point result by Arveson and an algebro-geometric method that relies on Bézout's theorem. The latter allows lifting the results from the single copy level to the case of multiple copies. Based on [1].

   [1] A. Bluhm, L. Rauber, M.M. Wolf, preprint `arXiv:1708.04898`

4. **Libor Caha:** FEYNMAN-KITAEV COMPUTER'S CLOCK: BIAS, GAPS, IDLING AND PULSE TUNING
   Joint work with Zeph Landau and Daniel Nagaj

   We present a collection of results about the clock in Feynman's computer construction and Kitaev's Local Hamiltonian problem. First, by analyzing the spectra of quantum walks on a line with varying endpoints, we find a better lower bound on the gap of the Feynman Hamiltonian, which translates into a less strict promise gap requirement for the QMA-complete Local Hamiltonian problem. Second, introducing an idling clock construction with a large state space, we provide a way for achieving an arbitrarily high success probability of computation with Feynman's computer with only a logarithmic increase in the number of clock qubits. Finally, we tune and thus improve the costs (locality, gap scaling) of implementing a (pulse) clock with a single excitation.

5. **Frédéric Dupuis:** SECURE CERTIFICATION OF MIXED QUANTUM STATES WITH APPLICATION TO TWO-PARTY RANDOMNESS GENERATION
   Joint work with Serge Fehr, Philippe Lamontagne, and Louis Salvail

   We investigate sampling procedures that certify that an arbitrary quantum state on n subsystems is close to an ideal mixed state $\varphi^{\otimes n}$ for a given reference state φ, up to errors on a few positions. This task makes no sense classically: it would correspond to certifying that a given bitstring was generated according to some desired probability distribution. However, in the quantum case, this is possible if one has access to a prover who can supply a purification of the mixed state. In this work, we introduce the concept of mixed-state certification, and we show that a natural sampling protocol offers secure certification in the presence of a possibly dishonest prover: if the verifier accepts then he can be almost certain that the state in question has been correctly prepared, up to a small number of errors. We then apply this result to two-party quantum coin-tossing: we construct a coin-tossing protocol while produces a common high-entropy source, where the entropy is an arbitrarily small fraction below the maximum.

6. **Sergey Filippov:** LOWER AND UPPER BOUNDS ON CLASSICAL CAPACITY OF NONUNITAL CHANNELS

   Classical capacity of unital qubit channels is well known, whereas that of nonunital qubit channels is not. We find lower and upper bounds on classical capacity of nonunital qubit channels by using a recently developed decomposition technique relating nonunital and unital positive qubit maps. Using a quantum analogue of Sinkhorn's theorem, we present a generalization of such an approach for quantum channels on Hilbert spaces of larger dimension.

7. **Jędrzej Kaniewski:** SELF-TESTING OF QUTRIT SYSTEMS

   Joint work with Antonio Acín, Remigiusz Augusiak, Flavio Baccari, Alexia Salavrakos, Ivan Šupic, and Jordi Tura

   Self-testing refers to the phenomenon of identifying the quantum state and measurements performed on it solely from the observed (nonlocal) statistics. Most existing self-testing results have been proven for qubits and the ones that apply to higher-dimensional systems are inherently based on qubit results. It might therefore seem puzzling that not a single self-testing result is known, which does not rely on self-testing of qubits. In this work we present two new self-testing results for qutrits which in no way rely on qubit self-testings. In both cases we self-test the maximally entangled state of two qutrits, whereas the measurements correspond to two natural classes of higher-dimensional measurements: (a) mutually unbiased bases and (b) CGLMP measurements.

8. **Aleksandra Krawiec:** VERTICES CANNOT BE HIDDEN FROM QUANTUM SPATIAL SEARCH FOR ALMOST ALL RANDOM GRAPHS

   Joint work with Adam Glos, Ryszard Kukulski, and Zbigniew Puchała

   In this paper we show that all nodes can be found optimally for almost all random Erdős-Rényi $\mathcal{G}(n,p)$ graphs using continuous-time quantum spatial search procedure. This works for both adjacency and Laplacian matrices, though under different conditions. The first one requires $p = \omega(\log^8(n)/n)$, while the seconds requires $p \geq (1+\varepsilon)\log(n)/n$, where $\varepsilon > 0$. The proof was made by analyzing the convergence of eigenvectors corresponding to outlying eigenvalues in the $\|\cdot\|_\infty$ norm. At the same time for $p < (1-\varepsilon)\log(n)/n$, the property does not hold for any matrix, due to the connectivity issues. Hence, our derivation concerning Laplacian matrix is tight.

9. **Wieslaw Laskowski:** MULTIPARTITE NONLOCALITY AND RANDOM MEASUREMENT

   Joint work with Anna de Rosier, Jacek Gruca, Fernando Parisio, and Tamás Vértesi

   We present an exhaustive numerical analysis of violations of local realism by families of multipartite quantum states. As an indicator of nonclassicality we employ the probability of violation for randomly sampled observables. Surprisingly, it rapidly increases with the number of parties or settings and even for relatively small values local realism is violated for almost all observables. We have observed this effect to be typical in the sense that it emerged for all investigated states including some with randomly drawn coefficients. We also present the probability of violation as a witness of genuine multipartite entanglement.

10. **Daniel Nagaj:** SHORTER UNENTANGLED PROOFS FOR GROUND STATE CONNECTIVITY

    Joint work with Libor Caha and Martin Schwarz

    We present a quantum problem where one can considerably shorten a proof by using a QMA(2) protocol with two unentangled provers. Meanwhile, the completeness-soundness gap of the original protocol shrinks polynomially. Our method is inspired by short unentangled proofs for NP. In particular, we show that when the QCMA-complete Ground State Connectivity (GSCON) problem for a system of size N has a proof of length $m = N^a$, we can construct a (2-copy, unentangled) proof in QMA(2) with length proportional to N.

11. **Miguel Navascues:** RESETTING UNCONTROLLED QUANTUM SYSTEMS

    We study the feasibility of causing the state of a closed quantum system leap backwards in time. The system (the target) is out of our control: this means that we ignore both its free Hamiltonian and how the system interacts with other quantum systems we may use to influence it. Under these conditions, we prove that there exist protocols within the framework of non-relativistic quantum physics which reset the target system to its exact quantum state at a given past time. Each "resetting protocol" is successful with non-zero probability for all possible free Hamiltonians and interaction unitaries, save a subset of zero measure. When the target is a qubit, the simplest resetting circuits have a significant average probability of success and their implementation is within reach of current quantum technologies. Finally, we find that, in case the resetting protocol fails, it is possible to run a further protocol that, if successful, undoes both the natural evolution of the target and the effects of the failed protocol over the latter. By chaining in this fashion several such protocols, one can substantially increase the overall probability of a successful time leap.

12. **Martí Perarnau-Llobet:** QUANTUM METROLOGY WITH ONE-DIMENSIONAL SUPERRADIANT PHOTONIC STATES

    Joint work with Vanessa Paulisch, Alejandro González-Tudela, and Ignacio Cirac

    Photonic states with large and fixed photon numbers, such as Fock states, enable quantum-enhanced metrology but remain an experimentally elusive resource. A potentially simple, deterministic and scalable way to generate these states consists in fully exciting N quantum emitters equally coupled to a common photonic reservoir, which leads to a collective decay known as Dicke superradiance. The emitted N-photon state turns out to be highly non-linear, and to characterise its metrological properties in this work we: (i) develop theoretical tools to compute the Quantum Fisher Information of general non-linear multi-mode photonic states as inputs of a Mach-Zender interferometer; (ii) use it to show that Dicke superradiant photons in 1D waveguides can achieve Heisenberg scaling, which can be saturated by a parity measurement; (iii) and show the robustness of these states to experimental limitations in state-of-art atom-waveguide QED setups.

13. **Chris Perry:** ELEMENTARY THERMAL OPERATIONS

    Joint work with Matteo Lostaglio and Alvaro M. Alhambra

    To what extent do thermodynamic resource theories capture physically relevant constraints? Inspired by quantum computation, we define a set of elementary thermodynamic gates that only act on 2 energy levels of a system at a time. We show that this theory is well reproduced by a Jaynes-Cummings interaction in rotating wave approximation and prove that elementary thermal operations present tighter constraints on the allowed transformations than thermal operations. Mathematically, this illustrates the failure at finite temperature of fundamental theorems concerning stochastic maps. Physically, this implies that stronger constraints can be given if we tailor a thermodynamic resource theory to the relevant experimental scenario and we provide new tools to do so. As an application, we investigate how our resource theories can be applied to Heat Bath Algorithmic Cooling, providing improved protocols for cooling systems.

14. **Zbigniew Puchała:** COHERIFYING QUANTUM CHANNELS

    Joint work with Kamil Korzekwa, Stanisław Czachórski, and Karol Życzkowski

    Is it always possible to explain random stochastic transitions between states of a finite-dimensional system as arising from the deterministic quantum evolution of the system? If not, then what is the minimal amount of randomness required by quantum theory to explain a given stochastic process? Here, we address this problem by studying possible *coherifications* of a quantum channel Φ, i.e., we look for channels $\Phi^{\mathcal{C}}$ that induce the same classical transitions T, but are "more coherent". To quantify the coherence of a channel Φ we measure the coherence of the corresponding Jamiołkowski state J_Φ. We show that the classical transition matrix T can be coherified to reversible unitary dynamics if and only if T is unistochastic. Otherwise the Jamiołkowski state $J_\Phi^{\mathcal{C}}$ of the optimally coherified channel is mixed, and the dynamics must necessarily be irreversible. To asses the extent to which an optimal process $\Phi^{\mathcal{C}}$ is indeterministic we find explicit bounds on the entropy and purity of $J_\Phi^{\mathcal{C}}$, and relate the latter to the unitarity of $\Phi^{\mathcal{C}}$. We also find optimal coherifications for several classes of channels, including all one-qubit channels. Finally, we provide a non-optimal coherification procedure that works for an arbitrary channel Φ and reduces its rank (the minimal number of required Kraus operators) from d^2 to d.

15. **Vilasini Venkatesh:** COMPOSABLE SECURITY IN RELATIVISTIC QUANTUM CRYPTOGRAPHY

    Joint work with Christopher Portmann and Lídia del Rio

    Relativistic protocols have been proposed to overcome certain impossibility results in classical and quantum cryptography but composing specific relativistic bit commitment protocols to construct other cryptographic resources is known to be insecure. To make general statements about such constructions, a framework for handling composable constructions in Minkowski space is required. We propose such a framework and show that (1) fair and unbiased coin flipping can be constructed from a new resource, a channel with delay (2) Biased coin flipping, bit commitment and channel with delay through any classical/quantum/relativistic protocol are all impossible without further assumptions (3) It is impossible to securely increase the "commitment time" of a channel with delay even if one is given n channels with delay to start with.

Posters

1. **Fabian Bernards:** On the Generalisation of Daemonic Gain in Ergotropy

   For a given state, the daemonic gain is the additional extractable energy via a unitary channel by measuring an ancilla. The concept was introduced by Francica et al. and they established a connection between the daemonic gain and measures of correlations [1].

   We present a numerical method to compute the daemonic gain using a see-saw mechanism and utilising the relation to state discrimination. For projective measurements, we show that the original definition of daemonic gain does not characterise entanglement. We extend the daemonic ergotropy to generalised measurements and show this can give an advantage. We then investigate the generalisation of the daemonic gain for three qubits and demonstrate that it can discriminate different entanglement classes.

   [1] G. Francica, J. Goold, F. Plastina, M. Paternostro, NPJ Quant. Inf. **3,** 12 (2017)

2. **Konstantin Beyer:** Dynamical quantum steering of an open qubit

   Joint work with Kimmo Luoma, and Walter T. Strunz

   We investigate quantum steering of an open quantum system by measurements on its environment in the framework of collision models. As an example we consider a coherently driven qubit dissipatively coupled to a bath. We construct local nonadaptive and adaptive as well as nonlocal measurement scenarios specifying explicitly the measured observable on the environment. Our approach shows transparently how the conditional evolution of the open system depends on the type of the measurement scenario and the measured observables. Further, we investigate the robustness of the constructed scenarios against thermal noise. Surprisingly, the system can be steered even when bipartite entanglement between the system and individual subenvironments vanishes.

3. **Jakub Jan Borkała:** Multiparty Distributed Quantum Random Access Codes

   Joint work with Debashis Saha

   Quantum random access code is one of the important communication complexity tasks which serves as a primitive for many quantum information processing protocols. In this work, we present generalized distributed Entanglement Assisted Random Access Code (dEARAC) using concatenation. Our scheme involves an arbitrary number of devices which are connected linearly. Furthermore we present method of generalisation of distributed Quantum Random Access Codes (dQRAC) with the use of particular symmetries in encoding/decoding strategy. We also justify why it is not possible to generalize dQRAC to an arbitrary number of inputs. Our goal is to introduce protocols that give a bigger gap between classical and quantum strategies that could be explored experimentally.

4. **Tom Bullock:** Characterising Optimal Error Bounds for Qubits

   Joint work with Paul Busch

   Incompatible observables are an unavoidable feature of quantum theory. In order obtain *some* information about two incompatible observables A, B, we can jointly measure two compatible *approximate* observables C, D. The degree that C (D) approximates A (B) can be quantified via an *error measure* $\delta(\mathsf{C}, \mathsf{A})$, leading to an *error tradeoff relation* $f\left(\delta(\mathsf{C}, \mathsf{A}), \delta(\mathsf{D}, \mathsf{B})\right) \geq g(\mathsf{A}, \mathsf{B})$. Any pair of approximating observables saturating such an inequality are considered *optimal*, with the choice of error measure influencing the optimal approximators. We consider optimal approximators for two incompatible qubit observables via two different intuitive measurement errors, the resulting tradeoff relations, and their operational meaning.

5. **Shin-Liang Chen:** Exploring the framework of assemblage moment matrices and its applications in device-independent characterizations

   In our recent work, a framework known by the name of assemblage moment matrices (AMMs) has been introduced for the device-independent (DI) quantification of quantum steerability and measurement incompatibility. Here, we further explore the framework of AMMs and compare the DI bounds obtained therefrom for entanglement robustness and incompatibility robustness against that of an alternative approach. When considering a Bell-type experiment in a tri- or more-partite scenario, we also show that the framework of AMMs provides a natural way to characterize the set of quantum correlations when post-quantum steering is allowed.

6. **Mikołaj Czechlewski:** Efficient device independent dimension witness of arbitrary quantum systems employing binary outcome measurements

   Joint work with Debashis Saha, Armin Tavakoli, and Marcin Pawłowski

   Device independent dimension witnesses (DW) are a remarkable way to test the dimension of a quantum system in a prepare-and-measure scenario imposing minimal assumptions on the internal features of the devices. However, as the dimension increases, the major obstacle in the realization of DW arises due to the requirement of many outcome quantum measurements. In this article, we propose a new variant of a widely studied communication task (random access code) and take its average payoff as the DW. The presented DW applies to arbitrarily large quantum systems employing only binary outcome measurements.

7. **Máté Farkas:** SELF-TESTING MUTUALLY UNBIASED BASES IN THE PREPARE-AND-MEASURE SCENARIO

   We show that 2-to-1 quantum random access codes are optimised uniquely by measurements corresponding to mutually unbiased bases. Therefore, they provide an ideal self-test in the prepare-and-measure scenario for mutually unbiased bases in arbitrary dimension — that is, we can characterise the measurements based solely on their outcome statistics. In dimensions where there is only one equivalence class of pairs of mutually unbiased bases, this characterisation is up to a unitary transformation and a global complex conjugation. Moreover, they self-test the states used on the encoding side in the same manner. While proving this result, we also provide a necessary condition for saturating an operator norm-inequality derived by Kittaneh.

8. **Piotr Gawron:** HYPER-SPECTRAL IMAGE SEGMENTATION USING ADIABATIC QUANTUM COMPUTATION

   Supervised machine learning techniques are widely used for classification of pixels in hyper-spectral images. A typical simple scheme of classification of such images probabilistically assigns a label to each individual pixel omitting information about pixel surroundings. In order to achieve better classification results for real images one has to agree the local label obtained from the classifier with the classes of pixel neighbourhood. One way to achieve this goal is to use Ising models. Where class probability is mapped to spin energy and class-class interaction is mapped to the spins coupling. By finding low energy states of such an Ising model we can find good classification results. Finding low-energy states of Ising models can be done using quantum adiabatic computers.

9. **Antonio Sebastian Rosado González:** THE EFFECT OF LORENTZ TRANSFORMATIONS ON QUANTUM OBSERVABLES AND REDUCED DENSITY MATRICES

   As an introduction we will present some useful concepts from relativistic quantum mechanics, such as the little group and the complementary set. Using these concepts and the transformation laws for the generators of the Poincaré group, we obtain general quantum observables which will be defined in any reference frame of the system. Following the work of Taillebois and Avelar, we will derive effective reduced density matrices from these general observables.

10. **Felix Huber:** EXPONENTIALLY MANY MONOGAMY AND CORRELATION CONSTRAINTS FOR MULTIPARTITE STATES

    Joint work with Christopher Eltschka, Otfried Gühne, and Jens Siewert

    We present an exponentially large family of correlation constraints that are applicable to all multipartite quantum systems of finite dimensions. These are stated in terms of linear entropies or purities of reductions. Our relations are obtained by defining and investigating a generalization of the universal state inversion map. This map can, surprisingly, directly be linked to Rains' shadow inequalities [1]. In case of pure states our correlation constraints turn into monogamy relations that govern the distribution of bipartite entanglement in multipartite quantum systems.

    [1] E.M. Rains, IEEE Trans. Inf. Theory **46,** 54 (2000)

11. **Tomasz Januszek:** IMPACT OF GLOBAL AND LOCAL INTERACTION ON QUANTUM SPATIAL SEARCH ON CHIMERA GRAPH

    Chimera graph, which represents the topology of D-Wave's quantum computer, has two-level structure. It is a grid graph, with complete-bipartite graph in each node. While the grid graph is known to have low efficiency for continuous-time quantum spatial search, this is not the case for complete bipartite-graph, which achieves optimal search complexity. In our work we analyse the chimera graph in order to determine how locally efficient topology affects the complexity of the algorithm on whole graph.

12. **Niklas Johansson:** EFFICIENT SIMULATION OF SOME QUANTUM COMPUTER ALGORITHMS

    Joint work with Jan-Åke Larsson

    A long-standing aim of quantum information research is to understand what gives quantum computers their advantage. Such an understanding would be of great benefit when attempting to build a quantum computer. Here we present a framework that uses classical resources but still is able to efficiently run, for example Deutsch-Jozsa and Simon's algorithms, and also can run Shor's factoring algorithm with some systematic errors. We have also showed this explicitly by factoring 15 using classical pass-transistor logic, with smaller systematic errors than any former experimental implementation, and the same amount of resources in time and space as a scalable quantum computer. Our results give further insight into the resources needed for quantum computation.

13. **Mátyás Koniorczyk:** NONLOCAL BEHAVIORS AND GAME-THEORETIC NARRATIVES

    We present an ongoing work which aims at finding interpretations of bipartite nonlocal behaviors as well as operational characterizations of the strength of nonlocality present in them. We revisit various nonlocal games (e.g. the CHSH game and its generalizations) known from the literature and seek for other non-cooperative classical games that can be possibly constructed so that they benefit from nonlocal coordination. We anlyze their features the presence of coordination realized by a possibly imperfect quantum or no-signaling device. We study the dependence of the game characteristics, such as the expected payoff on the other parameters of the behavior of the device, including 1-norm distance from the local polytope, statistical strength, etc.

14. **Ryszard Kukulski:** STRATEGIES FOR OPTIMAL SINGLE-SHOT DISCRIMINATION OF QUANTUM MEASUREMENTS
    Joint work with Zbigniew Puchała, Łukasz Pawela, and Aleksandra Krawiec

    The problem of discriminating quantum measurements is of the utmost importance in modern quantum information science. Imagine we have an unknown measurement device, a blackbox. The only information we have is that it performs one of two measurements, say S and T. Our goal is to tell whether it is possible to discriminate S and T perfectly, i.e. with probability equal to one and if is not possible, we would like to know how to compute the diamond norm of $S - T$ easily. In our work we show how to calculate the diamond norm and how to obtain the optimal state for discrimination. It is done by using SDP, convex programming and controlling the movement of the numerical range of unitary matrix under matrices multiplication.

15. **Dariusz Kurzyk:** UNCONDITIONAL SECURITY OF A K-STATE QUANTUM KEY DISTRIBUTION PROTOCOL
    Joint work with Łukasz Pawela and Zbigniew Puchała

    Quantum key distribution protocols constitute an important part of quantum cryptography, where the security of sensitive information arises from the laws of physics. In this paper we introduce a new family of key distribution protocols and we compare its key with the well-known protocols such as BB84, PBC0 and generation rate to the well-known protocols such as BB84, PBC0 and R04. We also state the security analysis of these protocols based on the entanglement distillation and CSS codes techniques.

16. **Paulina Lewandowska:** MONOTONICITY OF THE AVERAGE SINGULAR VALUES OF GINIBRE MATRICES

    We study to mononicity of the average singular value of random matrices sampled from the Ginibre enseblems of finite dimension d. We consider the case of complex ensemble (Dyson index $\beta = 2$), real enseble $\beta = 1$ and quaternion ensemble $\beta = 1$. This issue is of great importance in classical and quantum machine learning. For years has been conjectured that for $\beta = 2$ the average singular values decreses with d and for $\beta = 1$ it increses with d. Simple numerical simulation shows that in the case when $\beta = 4$ this quantity decreases with d. Our main aim to create a mathematical framework which, on the one hand, allows us to recover Abreu's results and, on the other hand, prove our conjectures for $\beta = 1$ and $\beta = 4$.

17. **Justyna Łodyga:** DO CLOSED TIMELIKE CURVES VIOLATE THE SECOND LAW OF THERMODYNAMICS?

    General relativity predicts existence of closed timelike curves. This is a surprising phenomenon as it leads to logical paradoxes such as the grandfather paradox. In the last thirty years Deutsch as well as Bennett and Schumacher proposed two models which avoid logical paradoxes. However these models have surprising implications on quantum mechanics. In this work we show that they can violate the second law of thermodynamics. In particular, we construct quantum circuits with qudits on closed timelike curves which enable to decrease entropy of chronology respecting qudits.

18. **Edgar Aguilar Lozano:** RANDOMNESS CERTIFICATION UNDER REALISTIC ASSUMPTIONS

    True randomness may only be guaranteed in the Device-Independent scenario, where we do not trust the physical devices that are used to generate random numbers. Randomness is certified only by the measurement outcome statistics, and the violation of a Bell-type inequality. In practice, the mass production of devices which violate loophole-free Bell inequalities is still out of reach. Hence, solutions for the near future are needed. In this work we present a framework for certifying randomness in the measurement-device independent scenario — that is, no assumptions are made about the detectors. The protocol gives a direct trade-off between the assumptions the user makes, and the amount of generated randomness. As a test-bed for our method, we look at a modified Mach-Zehnder interferometer.

19. **Kimmo Luoma:** PARAMETRIZATION AND OPTIMIZATION OF GAUSSIAN NON-MARKOVIAN UNRAVELINGS FOR OPEN QUANTUM DYNAMICS

    We derive a family of Gaussian non-Markovian stochastic Schrödinger equations for the dynamics of open quantum systems. The different unravelings correspond to different choices of squeezed coherent states, reflecting different measurement schemes on the environment. Consequently, we are able to give a single shot measurement interpretation for the stochastic states and microscopic expressions for the noise correlations of the Gaussian process. By construction, the reduced dynamics of the open system does not depend on the squeezing parameters. They determine the non-Hermitian Gaussian correlation, a wide range of which are compatible with the Markov limit. We demonstrate the versatility of our results for quantum information tasks in the non-Markovian regime. In particular, by optimizing the squeezing parameters, we can tailor unravelings for improving entanglement bounds or for environment-assisted entanglement protection.

20. **Luděk Matyska:** TOMOGRAPHY OF UNITARY AND RANDOM UNITARY

    We present our ongoing work in studying quantum process tomography of unitary and random unitary maps. Quantum process tomography consists of choosing a set of probe states, applying an unknown channel to these probes and then performing measurements on the outcomes of this process to fully characterize the unkown channel. Efficient process tomography of unitary maps has been previously studied both in the context of general process POVMs, allowing the use of an ancilla system and measurements on it, and while limiting the measurements only to states without any ancillas. We attempt to further analyze the minimal sets of states and measurements needed to characterize a unitary map and to extend these results to random unitary maps, with focus on random unitary maps acting on a multipartite system consisting of multiple copies of the same subsystem. This helps us identify and analyze unitary t-designs and their applications.

21. **Nikolai Miklin:** CAUSAL INEQUALITIES FROM VARIABLE-ELIMINATION METHODS

    We discuss derivation of causal inequalities, that bound a set of correlations compatible with an assumption of a definite causal order. In [1] the authors propose a method of deriving causal inequalities that is based on constructing a convex hull of the extremal points corresponding to different causal orders. In this work we present an alternative way to obtain causal polytopes using variable-elimination methods, such as Fourier-Motzkin elimination method. We show that this method is more efficient in calculating causal polytopes in comparison to the one proposed earlier. In particular, we present new inequalities, corresponding to the cases of more measurement outcomes and more settings, as well as the tripartite causal inequalities.

    [1] C. Branciard, M. Araújo, F. Costa, A. Feix, Č. Brukner, New J. Phys. **18,** 013008 (2016)

22. **Piotr Mironowicz:** CONNECTIONS BETWEEN MUTUALLY UNBIASED BASES AND QUANTUM RANDOM ACCESS CODES

    Joint work with Edgar A. Aguilar, Jakub J. Borkała, and Marcin Pawłowski

    We present a new quantum communication complexity protocol, the promise–Quantum Random Access Code, which allows us to introduce a new measure of unbiasedness for bases of Hilbert spaces. The proposed measure possesses a clear operational meaning and can be used to investigate whether a specific number of mutually unbiased bases exist in a given dimension by employing Semi–Definite Programming techniques.

23. **Nikolay Nahimov:** ON THE PROBABILITY OF FINDING MARKED CONNECTED COMPONENTS USING QUANTUM WALKS

    Finding a marked vertex in a graph can be a complicated task when using quantum walks. Recent results show that for two or more adjacent marked vertices search by quantum walk with Grover's coin may have no speed-up over classical exhaustive search. In this paper, we analyze the probability of finding a marked vertex for a set of connected components of marked vertices. We prove two upper bounds on the probability of finding a marked vertex and sketch further research directions.

24. **Mateusz Ostaszewski:** GEOMETRICAL VERSUS TIME-SERIES REPRESENTATION OF DATA IN LEARNING QUANTUM CONTROL

    We study the application of machine learning methods based on a geometrical and time-series character of data in the application to quantum control. We demonstrate that recurrent neural networks posses the ability to generalize the correction pulses with respect to the level of noise present in the system. We also show that the utilisation of the geometrical structure of control pulses is sufficient for achieving high-fidelity in quantum control using machine learning procedures.

25. **Jaroslav Pavličko** and **Mário Ziman:** EQUIVALENCE OF PROGRAMMABLE QUANTUM PROCESSORS

    Programmable quantum processor is a device that has two quantum registers –âĂŞ data and program. The state of the program register determines which completely positive map (program) on the data register is applied. By definition two processors are equivalent if they implement the same set of programs on states of the data register. For example, any post-processing of the program register generates equivalent processors. We will show that such post-processing equivalence is not a necessary condition for processors' equivalence. Further, we will formulate and investigate the equivalence relations in various settings, e.g. for restricted class of processors and probabilistic settings.

26. **Łukasz Pawela:** SPECTRUM BROADCAST STRUCTURES IN SPIN STAR SYSTEMS

    Joint work with Paweł Horodecki, Jarosław Korbicz, and Zbigniew Puchała

    In this work we study the possibility of formation os spectrum broadcast structure in spin star systems. These are systems which consist of one central qubit interacting with N environmental qubits via a Heisenberg interaction. This problem was widely studied by Żurek. We modify the interaction Hamiltonian, by adding a small σ_x perturbation. We show that the broadcast structure does not form. Furthermore, we show that after tracing out all but one environments, the state becomes entangled. In the thermodynamic limit $N \to \infty$ we get that the entanglement tends to zero, which can be explained with the usage of monogamy relations.

27. **Matěj Pivoluška:** TENSOR VALUED HYPERGRAPH STATES

    Joint work with Marcus Huber, Giuseppe Vitagliano, David W. Lyons, Alexander J. Heilman and Ezekiel W. Wertz

    We define a novel set of multipartite high-dimensional quantum states, which can encode any finite function over arbitrary Galois field $GF(k)$. Each of these states has a tensor valued hypergraph representation, which we use to study their properties, especially their local unitary equivalences.

28. **Martin Plávala:** CONDITIONS FOR THE COMPATIBILITY OF CHANNELS AND THEIR CONNECTION TO STEERING AND BELL NONLOCALITY

We formulate steering by channels and Bell nonlocality of channels as generalizations of the well-known concepts of steering by measurements and Bell nonlocality of measurements. The generalization does not follow the standard line of thinking stemming from the EPR paradox, but introduces steering and Bell nonlocality as entanglement-assisted incompatibility tests. The proposed definitions are, in the special case of measurements, the same as the standard definitions, but not all of the known results for measurements generalize to channels. For example we show that for quantum channels steering is not a necessary condition for Bell nonlocality.

29. **Martin Plesch:** LOSS OF INFORMATION IN QUANTUM GUESSING GAME

Joint work with Matej Pivoluska

Incompatibility of certain measurements — impossibility of obtaining deterministic outcomes simultaneously — is a well known property of quantum mechanics. This feature can be utilized in many contexts, ranging from Bell inequalities to device independent QKD protocols. Typically, in these applications the measurements are chosen from a predetermined set based on a classical random variable. One can naturally ask, whether the non-determinism of the outcomes is due to intrinsic hiding property of quantum mechanics, or rather by the fact that classical, incoherent information entered the system via the choice of the measurement. In our paper [1] we analyse a situation when the measurement selection is performed in a coherent way, controlled by a pure quantum state. We show that specifically for qubits, measurement result for any set of measurements with any a-priori probability distribution can be faithfully guessed by a suitable state preparation and measurement. We also show that up to a small set of specific cases, this is not possible for higher dimensions. This result manifests a deep difference in properties of qubits and higher dimensional systems and suggests that these systems might offer higher security in specific cryptographic protocols. More fundamentally, the results show that the impossibility of predicting a result of a measurement is not caused solely by a loss of coherence between the choice of the measurement and the guessing procedure.

[1] Martin Plesch, Matej Pivoluska, New J. Phys. **20,** 023018 (2018)

30. **Constantino Rodriguez Ramos:** CONVEX STRUCTURE OF THE SET OF DOUBLY-STOCHASTIC QUTRIT QUANTUM CHANNELS

We consider the convex classification of quantum channels. In particular, we consider the extreme points of the set of doubly-stochastic qutrit quantum channels. Examples of known extreme points are presented along with an analysis of the associated Choi matrix and its spectrum, thereby allowing a classification. We also discuss the choice of chosen basis for these extreme points, which we argue in terms of a systematic approach to finding new extreme points for the set of doubly-stochastic channels. Finally, we explore the possibility of extending our results to higher dimensions.

31. **Peter Rapčan:** AREA-LAW ENTANGLED EIGENSTATES CAN PRESERVE ERGODICITY

We study the ground state of the one-dimensional spin-1/2 Ising ferromagnet at its transverse-field critical point, which is an entangled state following the area law with a logarithmic correction. When this problem is expressed in terms of independent fermions, we show that the usual thermostatistical sums emerging within Fermi-Dirac statistics can, for an L-sized subsystem, be indistinctively taken up to L terms or up to $\ln L$ terms, providing an understanding of the origin of the logarithmic scaling of the entanglement entropy in the system. This is interpreted as a compact occupancy of the phase-space of the L-subsystem, hence standard Boltzmann-Gibbs thermodynamics quantities with an effective system size $V \equiv \ln L$ are appropriate and are explicitly calculated.

32. **Daniel Reitzner:** GROVER SEARCH UNDER LOCALIZED DEPHASING

Joint work with Mark Hillery

Decoherence in quantum searches and in Grover search leads very quickly to the loss of quadratic speedup over the classical case, when searching for some target element within a set of size N. The noise models used so far were, however, global. In this submission we study Grover search under the influence of localized partially dephasing noise of rate p. We find, that in the case when the size k of the affected subspace is much smaller than N, and the target is unaffected by the noise, namely when $kp \ll \sqrt{N}$, the quadratic speedup is retained. Once these restrictions are not met, the quadratic speedup is lost. We observe that in an intermediate region, where if $k \sim N^q$ and the target is unaffected, the speedup seems to obey N^q which can still be better than the classical case.

33. **Tomáš Rybár:** MEMORY REQUIREMENTS FOR GENERAL REVERSIBLE QUBIT STREAM PROCESSORS

There are two basic ways of describing a causal process: one is in terms of its input-output transformation alone. That is, we can determine the probability for any outcome of an arbitrary measurement on the outputs, given the joint state of all the inputs. The second way of describing such a map is in terms of its inner workings. It is usually easy to pass from the description of the internal circuitry to the input-output transformation, the inverse problem can in general be very hard. In this work we describe a complete solution of the inverse problem for the special case of reversible processes.

34. **Michal Sedlák:** PERFECT PROBABILISTIC STORING AND RETRIEVING OF UNITARY CHANNELS

If we have only limited access to a unitary transformation, we may want to store it into a quantum memory and later perfectly retrieve it. Thus, once we cannot use the unitary transformation directly anymore, we could still apply it to any state with the help of the footprint kept in the quantum memory. We require the storing and retrieving protocol to perfectly reconstruct the unitary transformation, which implies non unit probability of success. We derive optimal probability of success for a d-dimensional unitary transformation used N-times. The optimal probability of success has a very simple form $N/(N-1+d^2)$. This result implies that reliable storing of d^2 parameters of the unknown unitary transformation requires roughly d^2 uses of the transformation.

35. **Timo Simnacher:** ENTANGLEMENT DETECTION WITH SCRAMBLED DATA

Joint work with Nikolai Wyderka, René Schwonnek, and Otfried Gühne

In an ordinary entanglement detection scenario, the possible measurements and the corresponding data are given. We consider the situation where the data is scrambled. That means, the assignment of outcomes to probabilities is unknown because one has access only to a random permutation of the measured probabilities. This is in contrast to device-independent scenarios, where the measurements are not characterized but the data have a clear interpretation.

As an example, we investigate the two-qubit scenario with local measurements in mutually unbiased bases. Since entropies are naturally invariant under scrambling, they in principle provide a method to detect entanglement. It turns out that Shannon entropy is infeasible while generalized Tsallis and Rényi entropies can be useful. Another method are scrambling-invariant families of entanglement witnesses. However, the accessible scrambled data set of separable states is non-convex and therefore generally hard to characterize.

36. **Anna Szczepanek:** DYNAMICAL ENTROPY FOR QUTRITS: BEYOND RANK-ONE POVMS

Successive measurements are performed on a finite-dim quantum system evolving unitarily between two consecutive measurements. Such a process, generating sequences of measurement results and a Markov chain in the space of states, is modelled by a Quantum Iterated Function System. The irreducible randomness of results is quantified by the dynamical entropy, expressed by the Blackwell formula, whose evaluation requires the knowledge of the Markov chain generated by the system. If the measurement is a rank-one POVM, then we have a closed-form formula for dynamical entropy, yet in general no effective formula is known. We compute entropy in the case of qutrits measured with a PVM containing a rank-2 projector by determining the possible types of Markov chain such a system generates.

37. **Iskender Yalcinkaya:** IDEAL NEGATIVE MEASUREMENTS FOR A PHOTONIC QUANTUM WALK

Ideal negative measurements (INMs) are essential for a legitimate Leggett-Garg (LG) test of macrorealism. By means of a INM, one can acquire some information about the subject system without a direct interaction, which is in fact one of the assumptions that an LG test based on. We discuss here how INMs can be introduced to a current photonic time-multiplexing discrete-time quantum walk (QW) setup [1]. We further provide a simple QW scheme which is able to violate LG inequalities.

[1] T. Nitsche et al., preprint `arXiv:1803.04712`

38. **Xiao-Dong Yu:** DETECTING COHERENCE VIA SPECTRUM ESTIMATION

Joint work with Otfried Gühne

Quantum coherence is an essential resource in quantum information processing. Although the quantification of coherence has attracted a lot of theoretical interest, the lack of efficient methods to obtain the coherence of the quantum system in experiments limits its applications. In this letter, we address this problem by introducing a experiment-friendly method for spectrum estimation. With this method, we can not only witness the presence of coherence, but also get a rather precise estimation of coherence of the quantum system. As an application, we show how to witness the universal freezing phenomenon of coherence in experiments.

39. **Yichen Zhang:** NOISELESS LINEAR AMPLIFIERS IN CONTINUOUS VARIABLE MEASUREMENT DEVICE INDEPENDENT QUANTUM CRYPTOGRAPHY

Continuous-variable measurement-device-independent quantum key distribution (CV-MDI QKD) has been proposed to defend all attacks against detectors. But it is limited to much shorter secure transmission distance and less key rates. The main reason is the existence of excess noise combined with high losses in the quantum channels. To increase the maximal transmission distance of the CV-MDI QKD protocol, here, we propose a modified CV-MDI QKD protocol by inserting two noiseless linear amplifiers (NLAs), one at Alice's side and one at Bob's side. The successful use of NLAs make the modified protocol transmit longer distances and distribute more keys in the regime of small entanglement which is typical in realistic implementations.

25. **Mário Ziman** and **Jaroslav Pavličko:** EQUIVALENCE OF PROGRAMMABLE QUANTUM PROCESSORS

Invited talks

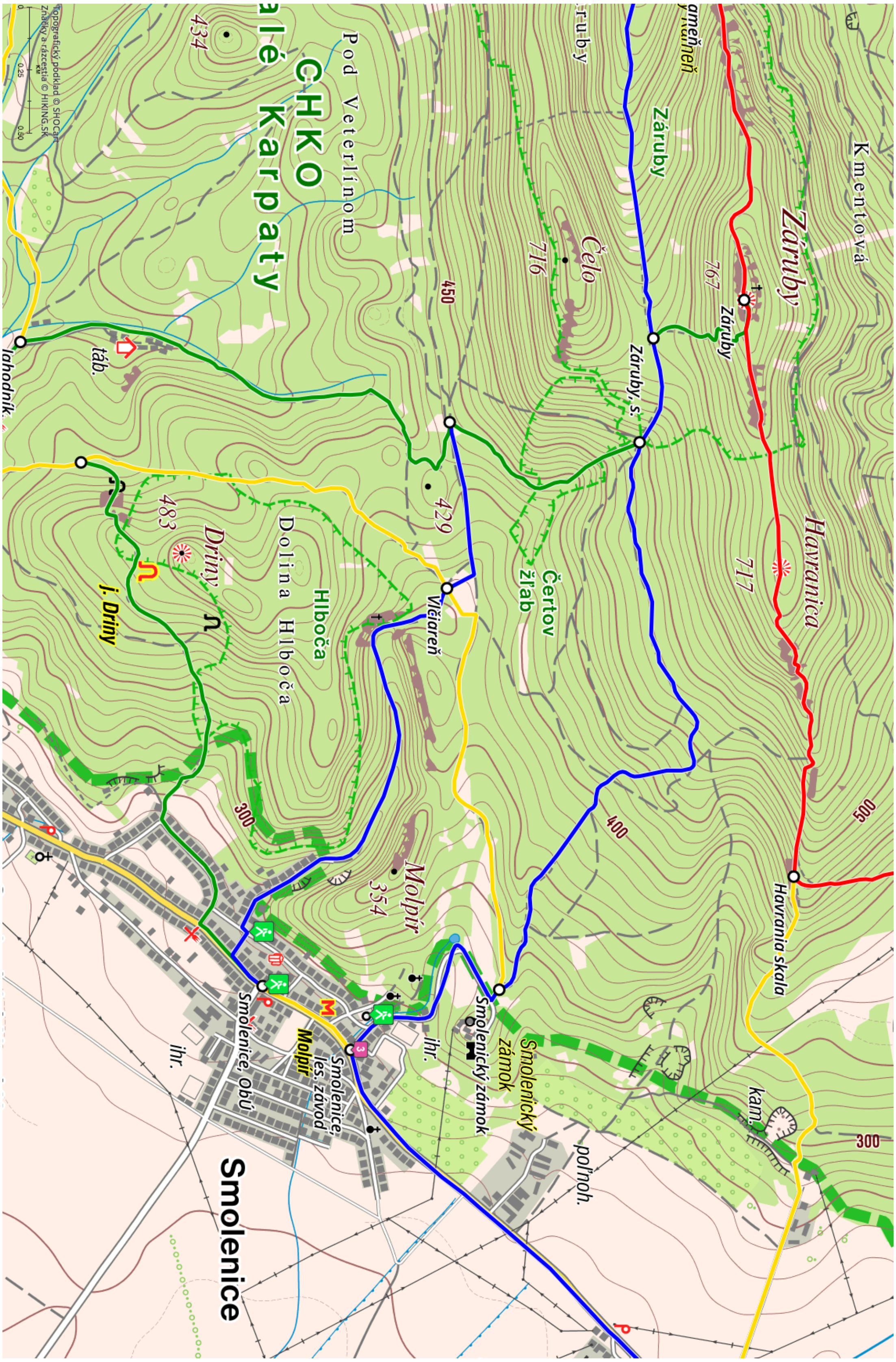
1. **Alessandro Bisio:** Higher order quantum computation
2. **Marcus Huber:** Thermodynamic limitations to quantum measurements
3. **Matthias Kleinmann:** Methods for a conclusive verification of bipartite bound entanglement
4. **Robert König:** Quantum advantage with shallow circuits
5. **Sergii Strelchuk:** TBA
6. **Tamás Vértesi:** Useful correlations from bound entangled states

Contributed talks

1. **Remigiusz Augusiak:** Bell inequalities for maximally entangled states
2. **Stefan Baeuml:** Fundamental limitations on the capacities of bipartite quantum interactions
3. **Andreas Bluhm:** Quantum compression relative to a set of measurements
4. **Libor Caha:** Feynman-Kitaev computer's clock: bias, gaps, idling and pulse tuning
5. **Frédéric Dupuis:** Secure Certification of Mixed Quantum States with Application to Two-Party Randomness Generation
6. **Sergey Filippov:** Lower and upper bounds on classical capacity of nonunital channels
7. **Jedrzej Kaniewski:** Self-testing of qutrit systems
8. **Aleksandra Krawiec:** Vertices cannot be hidden from quantum spatial search for almost all random graphs
9. **Wieslaw Laskowski:** Multipartite nonlocality and random measurement
10. **Daniel Nagaj:** Shorter unentangled proofs for Ground State Connectivity
11. **Miguel Navascues:** Resetting uncontrolled quantum systems
12. **Martí Perarnau-Llobet:** Quantum metrology with one-dimensional superradiant photonic states
13. **Chris Perry:** Elementary Thermal Operations
14. **Zbigniew Puchała:** Coherifying quantum channels
15. **Vilasini Venkatesh:** Composable security in relativistic quantum cryptography

Posters

1. **Fabian Bernards:** On the Generalisation of Daemonic Gain in Ergotropy
2. **Konstantin Beyer:** Dynamical quantum steering of an open qubit
3. **Jakub Jan Borkała:** Multiparty Distributed Quantum Random Access Codes
4. **Tom Bullock:** Characterising Optimal Error Bounds for Qubits
5. **Shin-Liang Chen:** Exploring the framework of assemblage moment matrices and its applications in device-independent characterizations
6. **Mikołaj Czechlewski:** Efficient device independent dimension witness of arbitrary quantum systems employing binary outcome measurements
7. **Máté Farkas:** Self-testing mutually unbiased bases in the prepare-and-measure scenario
8. **Piotr Gawron:** Hyper-spectral image segmentation using adiabatic quantum computation
9. **Antonio Sebastian Rosado González:** The effect of Lorentz transformations on quantum observables and reduced density matrices
10. **Felix Huber:** Exponentially many monogamy and correlation constraints for multipartite states
11. **Tomasz Januszek:** Impact of global and local interaction on quantum spatial search on chimera graph
12. **Niklas Johansson:** Efficient simulation of some quantum computer algorithms
13. **Mátyás Koniorczyk:** Nonlocal behaviors and game-theoretic narratives
14. **Ryszard Kukulski:** Strategies for optimal single-shot discrimination of quantum measurements
15. **Dariusz Kurzyk:** Unconditional Security of a K-State Quantum Key Distribution Protocol
16. **Paulina Lewandowska:** Monotonicity of the average singular values of Ginibre matrices
17. **Justyna Łodyga:** Do closed timelike curves violate the second law of thermodynamics?
18. **Edgar Aguilar Lozano:** Randomness Certification Under Realistic Assumptions
19. **Kimmo Luoma:** Parametrization and optimization of Gaussian non-Markovian unravelings for open quantum dynamics
20. **Luděk Matyska:** Tomography of Unitary and Random Unitary
21. **Nikolai Miklin:** Causal inequalities from variable-elimination methods
22. **Piotr Mironowicz:** Connections Between Mutually Unbiased Bases and Quantum Random Access Codes
23. **Nikolay Nahimov:** On the Probability of Finding Marked Connected Components Using Quantum Walks
24. **Mateusz Ostaszewski:** Geometrical versus time-series representation of data in learning quantum control
25. **Jaroslav Pavličko** and **Mário Ziman:** Equivalence of programmable quantum processors
26. **Łukasz Pawela:** Spectrum broadcast structures in spin star systems
27. **Matěj Pivoluška:** Tensor valued hypergraph states
28. **Martin Plávala:** Conditions for the compatibility of channels and their connection to steering and Bell nonlocality
29. **Martin Plesch:** Loss of Information in Quantum Guessing Game
30. **Constantino Rodriguez Ramos:** Convex structure of the set of doubly-stochastic qutrit quantum channels.
31. **Peter Rapčan:** Area-law entangled eigenstates can preserve ergodicity
32. **Daniel Reitzner:** Grover Search under Localized Dephasing
33. **Tomáš Rybár:** Memory requirements for general reversible qubit stream processors
34. **Michal Sedlák:** Perfect probabilistic storing and retrieving of unitary channels
35. **Timo Simnacher:** Entanglement detection with scrambled data
36. **Anna Szczepanek:** Dynamical entropy for qutrits: beyond rank-one POVMs
37. **Iskender Yalcinkaya:** Ideal negative measurements for a photonic quantum walk
38. **Xiao-Dong Yu:** Detecting Coherence via Spectrum Estimation
39. **Yichen Zhang:** Noiseless Linear Amplifiers in Continuous Variable Measurement Device Independent Quantum Cryptography



Scenic route: Smolenický zámok – [yellow] – Vlčiareň – [blue] – [green] – [blue] – [green] – Záruby – [red] – Havrania skala (viewpoint) – (unmarked path) – [blue] – Smolenický zámok