

Workshop on Learning Quantum Systems and Quantum Processes

General Information – Schedule – Abstracts

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General information

Venue: Conference Center of the University of Siegen, Obergraben 25, 57072 Siegen.

Talks: Monday, 29 September to Wednesday, 1 October 2025.

Format: 45+15 minutes / 20+10 minutes.

Conference Dinner: Monday 19:00, “Alter Weinkeller,” Heinstraße 1, 57072 Siegen.

eleQtron visit: Wednesday 16:15, Heeserstraße 5, 57072 Siegen

Organizers: Matthias Kleinmann, Otfried Gühne, Daniela Lehmann.

Participants

Salim Amin, University of Siegen

Raphael Brieger, IQM Munich

Matthias Caro, University of Warwick

Sophia Denker, University of Siegen

Niklas Euler, University of Jena

Julia Freund, University of Innsbruck

Jonas Fuksa, FU Berlin

Giulio Gasbarri, University of Siegen

Ahana Ghoshal, University of Siegen

Kiara Hansenne, CEA Paris Saclay

Mengying Hu, Hebei Normal University

Joel Huber, University of Siegen

Violeta Ivanova-Rohling, University of Konstanz

Arturo Konderak, Polish Academy of Sciences Warsaw

Tristan Kraft, TU München

Robin Krebs, TU Darmstadt

Kunal Kumbher, University of Siegen

Yien Liang, University of Düsseldorf

Elisa Monchetti, University of Siegen

Raphaël Mothe, University of Siegen

H. Chau Nguyen, University of Siegen

Ties Ohst, University of Siegen

Maike Reckermann, University of Jena

Jesus Rubio, University of Surrey

Leonardo Silva Viera Santos, University of Siegen

Marcel Seelbach, eleQtron Siegen

Ismaël Septembre, University of Siegen

Sander Stambach, University of Siegen

Abhishek Yadav, University of Siegen

Schedule

Monday, 29 September 19:30: Gathering at Ristorante Pizzeria Icardi, Kölner Straße 24 (contact Matthias).

Monday, 29 September

09:00	Matthias Caro	Verifiably delegating quantum learning with interactive proofs
10:00	Giulio Gasbarri	Sequential hypothesis testing for continuously-monitored quantum systems
10:30	Coffee	
11:00	Kiara Hansenne	Overlapping tomography: Efficient characterisation of qubit and fermionic systems
12:00	Maike Reckermann	Bounding the entanglement dimension in cold-atom quantum simulators using kinetic operators
12:30	Lunch	
14:00	Raphael Brieger	Characterizing fluctuating noise on superconducting quantum processors with compressed sensing
15:00	Yien Liang	Pathological behaviour of point estimators with minimum bias
15:30	Coffee	
16:00	Ahana Ghoshal	Optimising measurement of correlators for fermionic quantum simulators
16:30	Sophia Denker	Chiral symmetries and multiparticle entanglement
17:00	End	
19:00	<i>Conference Dinner</i>	

Tuesday, 30 September

- 09:00 Violeta Ivanova-Rohling On learning efficient and resilient quantum gates
- 10:00 Jonas Fuksa Robust learning of bosonic Hamiltonians
- 10:30 **Coffee**
- 11:00 Tristan Kraft Bounded-error quantum simulations through Hamiltonian and Lindbladian learning
- 12:00 Ismaël Septembre Characterisation of multi-partite entanglement beyond the Schmidt decomposition
- 12:30 **Lunch**
- 14:00 H. Chau Nguyen Shadow tomography and its applications
- 15:00 Arturo Konderak Self-testing Slater states
- 15:30 **Coffee**
- 16:00 Leonardo S. V. Santos Device-independent quantum memory certification in two-point measurement experiments
- 16:30 *Discussion on current and future topics*
- 17:30 **End**

Wednesday, 1 October

- 09:00 Jesus Rubio Symmetries and incompatibility in global multiparameter quantum metrology
- 10:00 Julia Freund Entanglement and purity can help to detect systematic experimental errors
- 10:30 **Coffee**
- 11:00 Niklas Euler A general scheme for learning phases of lattice-confined ultracold atomic clouds
- 11:30 Elisa Monchetti Making entanglement witnesses robust to measurement errors
- 12:00 **Lunch**
- Open discussions (Emmy–Noether-Campus)*
- 16:15 *Visit eleQtron*

Thursday, 2 October

Open discussions (Emmy–Noether-Campus).

Abstracts

Matthias Caro, University of Warwick,

Verifiably delegating quantum learning with interactive proofs.

Abstract. Quantum data access and quantum processing can make certain classically intractable learning tasks feasible. However, advanced quantum capabilities will only be available to a select few in the near future. Thus, reliable schemes that allow classical clients to delegate learning to untrusted quantum servers are required to facilitate widespread access to quantum learning advantages. In this talk, I will show how to formalise the challenge of verifiably delegating quantum learning in terms of so-called interactive proofs, and I will present some recent results about the power and limitations of such interactive proofs for achieving quantum learning advantages through delegation.

Sophia Denker, University of Siegen,

Chiral symmetries and multiparticle entanglement.

Abstract. Bosons and fermions are defined by their exchange properties and the underlying symmetries determine the structure of the corresponding state spaces. For two particles there are two possible exchange symmetries, resulting in symmetric or antisymmetric behaviour, but when exploring multiparticle systems also quantum states with chiral symmetries appear. In this work we demonstrate that chiral symmetries lead to extremal forms of quantum entanglement. More precisely, we show that subspaces with this symmetry are highly entangled with respect to the geometric measure of entanglement, leading to observables which can be useful for entanglement characterization. Along the way, we develop a simple method to solve the problem of genuine multiparticle entanglement for unitarily invariant three-particle states and use it to identify genuine multipartite entangled states whose partial transposes with respect to all bipartitions are positive. Lastly, we consider generalizations with less symmetry and show that these subspaces are even more entangled.

Julia Freund, University of Innsbruck,

Entanglement and purity can help to detect systematic experimental errors.

Abstract. Measurements are central in all quantitative sciences, and a fundamental challenge is to make observations without systematic measurement errors. This holds in particular for quantum information processing, where other error sources like noise and decoherence are unavoidable. Consequently, methods for detecting systematic errors have been developed, but the required quantum state properties are yet unexplored. We develop theoretically a direct and efficient method to detect systematic errors in quantum experiments and demonstrate it experimentally using quantum state tomography of photon pairs emitted from a semiconductor quantum dot. Our method can be scaled to multi-qubit systems, and we find that entanglement and quantum states with high purity can help identify systematic errors.

Giulio Gasbarri, University of Siegen,

Sequential hypothesis testing for continuously-monitored quantum systems.

Abstract. We explore sequential hypothesis testing for continuously monitored quantum systems, where real-time data analysis allows for early termination of experiments once a prescribed confidence level is achieved. This adaptive approach contrasts with traditional fixed-duration methods, enabling potential reductions in average measurement time. We analyze the stopping-time behavior of sequential tests and demonstrate their asymptotic advantages in terms of both efficiency and error control.

Ahana Ghoshal, University of Siegen,

Optimising measurement of correlators for fermionic quantum simulators.

Abstract. Simulating many-body fermionic systems in conventional qubit-based quantum computers poses significant challenges due to the overheads associated with the encoding of fermionic statistics in qubits, leading to the proposal of native fermionic simulators as an alternative. While allowing for fermionic problems to be simulated efficiently, this class of fermionic simulators carries also specific constraints with them and poses other challenges unfamiliar to qubit systems. Here, by pairing fermionic modes to form second quantised qubits, we show that the fermionic gates can be represented as rotations of the second-quantised qubits, enabling adaptation of methods for qubit systems. As an application, we use this pairing scheme to represent the measurement of two- and four-point correlators in fermionic simulators with its native gates as a graph problem. Optimising measurement settings is then analysed with various analytical and algorithmic methods.

Kiara Hansenne, CEA Paris Saclay,

Overlapping tomography: Efficient characterisation of qubit and fermionic systems.

Abstract. Characterising large-scale quantum systems is central to fundamental physics and essential for the development of quantum technologies. While full tomography demands exponentially growing resources, focusing on application-relevant information can often lead to a significantly simplified analysis. Overlapping tomography offers a promising approach by targeting specific parts of multipartite quantum systems, extracting relevant partial information with fewer resources. This framework applies broadly across different quantum platforms, including qubit-based devices and fermionic simulators. We develop optimised overlapping tomography protocols that minimise the number of measurement settings. We start with qubit systems where we make use of graph-theoretic techniques and connections to combinatorial covering arrays to show how to reduce the measurement overhead significantly. For example, we show that two-body nearest-neighbour marginals on planar qubit lattices require only nine Pauli measurement settings to be fully characterised. More generally, we prove that all k -body marginals can be reconstructed with 3^k projective measurements, independent of system size. We extend these ideas to many-body fermionic systems and take into account the challenges imposed by fermionic statistics and native gate constraints. By pairing fermionic modes into second-quantised qubits, we map the measurement of few-point correlators to graph problems that can be solved with tools from qubit

overlapping tomography. This enables efficient schemes for measuring two- and four-point correlators of fermionic systems. We find that the number of measurements scales linearly for two-point correlators and discuss the more demanding scaling of four-point correlators, illustrating the approach on common lattice geometries.

Arturo Konderak, Polish Academy of Sciences Warsaw,

Self-testing slater states.

Abstract. Self-testing is a procedure that refers to characterizing uniquely quantum states and quantum strategies from the set of quantum simulations. It has been proved that all entanglement quantum states can be self-tested in the bipartite case, while for general multipartite systems, a complete characterization is still missing. We propose a strategy that allows us to self-test a specific class of multiparticle states, namely, the Slater states, which are multipartite antisymmetric states. Interestingly this strategy is powerful as the number of local dimensions and measurement is constant and independent of the number of parties.

H. Chau Nguyen, University of Siegen,

Shadow tomography and its applications.

Abstract. Starting with a brief introduction to shadow tomography, we describe how it can be formulated for generalised measurements. We show that symmetric frameworks for shadow tomography are particularly robust, allowing mitigation of complex noise arising in the readout process. In particular, correlated readout noise in quantum computers can also be efficiently mitigated by extending shadow tomography with controlled randomised (qu)bit flips. We then demonstrate a (surprisingly) natural application of shadow tomography in the characterisation of relativistic spin–spin correlations of output particles in high-energy physics experiments. As an example, we discuss the recently experiment demonstrating top-quark entanglement at ATLAS and CMS.

Jesús Rubio, University of Surrey,

Symmetries and incompatibility in global multiparameter quantum metrology.

Abstract. Harnessing symmetry and geometry has recently emerged as a powerful strategy to enhance quantum metrology, especially when combined with Bayesian principles. These ideas have led to substantial gains in precision for finite sample sizes and physically meaningful priors, as demonstrated in a series of cold atom experiments. Yet, such advances have been mostly confined to single-parameter estimation, leaving the richer multiparameter landscape largely unexplored. In this talk, I will review key experimental insights and propose a Bayesian framework for multiparameter quantum estimation that systematically incorporates symmetry. I will discuss bounds on the true multiparameter optimum and identify a notion of estimation incompatibility, offering both theoretical insights and practical tools for the next generation of quantum sensors.

Leonardo Silva Viera Santos, University of Siegen,

Device-independent quantum memory certification in two-point measurement experiments.

Abstract. Quantum memories are the storage drives of quantum tech: they hold a quantum state and hand it back on demand without wrecking superposition and entanglement. Checking that claim matters for computing, crypto, and networks, yet there has not been a general, assumption-free way to do so. We offer one: a device-independent certification that does not ask you to trust any part of the hardware. It works by probing the system at two points in time and comparing the resulting temporal correlations against classical causal models, looking for violations of Bell-like inequalities. We run out a proof-of-principle demo on a trapped-ion quantum processor and certify a qubit memory for 40 ms.

Ismaël Septembre, University of Siegen

Characterisation of multi-partite entanglement beyond the Schmidt decomposition.

Abstract. Multi-partite entanglement is an incredible resource for quantum information processing, yet it is incredibly hard to assess. Standard methods for entanglement characterisation, such as PPT criterion or Schmidt decomposition, do not extend well to multi-partite scenarios. In our work, we aim to develop new methods capable of assessing the genuine multi-partite nature of entanglement in multi-level systems. To do this, we generalise the notion of Schmidt decomposition, building up on the framework of partition rank. We show that the decomposition we suggest refines the framework of genuine multi-partite entanglement dimension as well as Schmidt rank vectors that were developed previously.