QI 13: Quantum Information and Foundations II

Time: Friday 10:45–12:30 Location: H4

QI 13.1 Fri 10:45 H4

Genuine multipartite entanglement is not a precondition for secure conference key agreement — •Giacomo Carrara, Dagmar Bruss, Hermann Kampermann, and Gláucia Murta — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, D-40225 Düsseldorf, Germany

Entanglement plays a crucial role in the security of quantum key distribution. A secret key can only be obtained by two parties if there exists a corresponding entanglement-based description of the protocol in which entanglement is witnessed, as shown by Curty et al (2004). Here we investigate the role of entanglement for the generalization of quantum key distribution to the multipartite scenario, namely conference key agreement. In particular, we ask whether the strongest form of multipartite entanglement, namely genuine multipartite entanglement, is necessary to establish a conference key. We show that, surprisingly, a non-zero conference key can be obtained even if the parties share biseparable states in each round of the protocol. Moreover we relate conference key agreement with entanglement witnesses and show that a non-zero conference key can be interpreted as a non-linear entanglement witness that detects a class of states which cannot be detected by usual linear entanglement witnesses.

QI 13.2 Fri 11:00 H4

An algorithm for maximizing the geometric measure of entanglement — •Jonathan Steinberg and Otfried Gühne — Universität Siegen, Siegen, Deutschland

The characterization of multipartite entanglement is an important subject in order to make quantum advantages accessible for applications. One proper multipartite entanglement measure, i.e., a measure that does not rely on averages of bipartite entanglement, is the geometric measure. In this work we propose an algorithm which aims to find maximally entangled states with respect to the geometric measure. As it turns out, the algorithm's update rule constitutes a gradient descent, providing fast convergences and applicability to large systems. Surprisingly, we find that the maximally entangled states for a n-partite qudit system is in the case of existence always given by an AME(n,d) state, except for n=3, where the w-state maximizes the measure. However, for those cases where AME states do not exist, we present a family of states, called maximally marginal symmetric, that maximizes the geometric measure. Further we discuss how the algorithm could be utilized to find new AME states as AME(8,4).

QI 13.3 Fri 11:15 H4

Quantum correlations in time — •Tian Zhang[1], Oscar Dahlsten[1,2], and Vlatko Vedral[1,3,4] — [1]Clarendon Laboratory, University of Oxford, Oxford OX13PU, UK — [2]Institute for Quantum Science and Engineering, Department of Physics, Southern University of Science and Technology (SUSTech), Shenzhen 518055, China — [3]Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543 — [4]Department of Physics, National University of Singapore, Singapore 117542

We investigate quantum correlations in time in different approaches. We assume that temporal correlations should be treated in an even-handed manner with spatial correlations. We compare the pseudo-density matrix formalism with several other approaches: indefinite causal structures, consistent histories, generalised quantum games, out-of-time-order correlations(OTOCs), and path integrals. We establish close relationships among these space-time approaches in non-relativistic quantum theory, resulting in a unified picture. With the exception of amplitude-weighted correlations in the path integral formalism, in a given experiment, temporal correlations in the different approaches are operationally equivalent.

QI 13.4 Fri 11:30 H4

Some quantum measurements with three outcomes can reveal nonclassicality where all two-outcome measurements fail to do so — •Hai Chau Nguyen and Otfried Gühne — Department of Physics, University of Siegen

Measurements serve as the intermediate communication layer between the quantum world and our classical perception. So, the question of which measurements efficiently extract information from quantum systems is of central interest. Using quantum steering as a nonclassical phenomenon, we show that there are instances where the results of all two-outcome measurements can be explained in a classical manner, while the results of some three-outcome measurements cannot. This points to the important role of the number of outcomes in revealing the nonclassicality hidden in a quantum system. Moreover, our methods allow us to improve the understanding of quantum correlations by delivering novel criteria for quantum steering and improved ways to construct local hidden variable models.

QI 13.5 Fri 11:45 H4

On Quantum Sets of Non-Contextuality Inequalities — •Lina Vandré[1] and Marcelo Terra Cunha[2] — [1]Universität Siegen, Germany — [2]Universidade Estadualde Campinas, Brazil

Bell inequalities and other non-contextuality (NC) inequalities are fundamental for quantum information processing. The underlying scenarios can be represented by exclusivity graphs [1]. While a Bell or NC scenario has a unique graph, the same graph can correspond to different scenarios. Originally there is no distinction between parties. In Ref. [2], the approach got modified by using coloured graphs to represent scenarios of multiple parties. In general, coloured graphs describes the underlying Bell or NC scenarios more precisely. The mathematical properties of the graph are then used for finding the classical and the quantum bound of the inequality. Also the complete set of behaviours allowed by classical probability theory as well as the quantum set can be characterised using these methods.

In this contribution I will discuss the coloured graph approach to the CHSH inequality and provide a method to characterise the corresponding quantum set. Moreover, I introduce a family of subgraphs of the CHSH graph which have the same underlying non-coloured graph (shadow) as the CHSH graph but represent different Bell or NC scenarios. I will compare the quantum sets of different graphs from this family and show how changes in the graph influence the underlying scenario and the quantum set [3].

[1] Phys. Rev. Lett. 112, 040401 (2014) [2] J. Phys. A: Math. Theor. 47, 4240214 (2014) [3] arXiv:2105.08561

QI 13.6 Fri 12:00 H4

Relative entropic uncertainty relation for scalar quantum fields — Stefan Floerchinger, Tobias Haas, and •Markus Schröfl — Institut für Theoretische Physik, Universität Heidelberg, Heidelberg, Germany

Entropic uncertainty is a well-known concept to formulate uncertainty relations for continuous variable quantum systems with finitely many degrees of freedom. Typically, the bounds of such relations scale with the number of oscillator modes, preventing a straight-forward generalization to quantum field theories. In this work, we overcome this difficulty by introducing the notion of a functional relative entropy and show that it has a meaningful field theory limit. We present the first entropic uncertainty relation for a scalar quantum field theory and exemplify its behavior by considering few particle excitations.

QI 13.7 Fri 12:15 H4

Operational Theories in Phase Space: Toy Model for the Harmonic Oscillator — •Martin Plávala and Matthias Kleinmann — Naturwissenschaftlich-Technische Fakultät, Universität Siegen, 57068 Siegen, Germany

We construct a toy model for the harmonic oscillator that is neither classical nor quantum. The model features a discrete energy spectrum, a ground state with sharp position and momentum, an eigenstate with non-positive Wigner function as well as a state that has tunneling properties. The underlying formalism exploits that the Wigner–Weyl approach to quantum theory and the Hamilton formalism in classical theory can be formulated in the same operational language, which we then use to construct toy model with well-defined phase space. The toy model demonstrates that operational theories are a viable alternative to operator-based approaches for building physical theories.