# Q 8: Quantum Information: Concepts and Methods II

Time: Monday 17:00–19:00 Location: P 2

Q 8.1 Mon 17:00 P 2

**Theory-independent conclusions from bipartite quantum correlations** — •Matthias Kleinmann[1], Tamás Vértesi[2], and Adán Cabello[3] — [1]University of the Basque Country UPV/EHU, Bilbao, Spain — [2]Hungarian Academy of Sciences, Debrecen, Hungary — [3]University of Sevilla, Sevilla, Spain

Bell-inequalities enable us to test quantum theory against a particular class of alternative theories, the local hidden variable models. Recent experiments have thoroughly ruled out these models. In the same spirit we investigate a different set of nonsignaling theories, in which measurements of many outcomes are constructed by selecting from two-outcome measurements. We derive tight inequalities for this set of theories and show that experiments using current quantum technology can demonstrate a violation of these inequalities. This makes it possible to perform tests of the structure of measurements, independent of the underlying theory. Our method also generalizes to other traits of quantum theory and as an example we present a theory-independent test of the compatibility structure occurring in quantum theory.

Q 8.2 Mon 17:15 P 2

**Indistinguishability of causal relations from limited marginals** — Costantino Budroni[1], •Nikolai Miklin[1], and Rafael Chaves[2] — [1]Universität Siegen, Walter-Flex-Str. 3 , 57068 Siegen, Germany — [2]International Institute of Physics, 59070 - 405 Natal, Brazil

Deciding global properties of a given object from partial information is a problem often encountered in the most diverse fields. In probability theory this problem is known as the marginal problem: deciding whether a given set of marginal probability distributions for some random variables arises from a joint distribution of all these variables. Another important problem is of a causal inference which arises in many cases together with the marginal problem. This problem questions whether observed correlations are compatible with some underlined causal structure.

We investigate the possibility of distinguishing among different causal relations starting from a limited set of marginals. Our main tool is the notion of adhesivity, that is, the extension of probability or entropies defined only on subsets of variables, which provides additional independence constraints among them. Our results provide a criterion for recognizing which causal structures are indistinguishable when only limited marginal information is accessible. Furthermore, the existence of such extensions greatly simplifies the characterization of a marginal scenario, a result that facilitates the derivation of Bell inequalities both in the probabilistic and entropic frameworks, and the identification of marginal scenarios where classical, quantum, and postquantum probabilities coincide.

Q 8.3 Mon 17:30 P 2

**Entropic nonsignaling correlations** — •Costantino Budroni[1] and Rafael Chaves[2] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany — [2]International Institute of Physics, Universidade Federal do Rio Grande do Norte, 59070-405 Natal-RN, Brazil

We introduce the concept of entropic nonsignaling correlations, i.e., entropies arising from probabilistic theories that are compatible with the fact that we cannot transmit information instantaneously. We characterize and show the relevance of these entropic correlations in a variety of different scenarios, ranging from typical Bell experiments to more refined descriptions such as bilocality and information causality. In particular, we apply the framework to derive the first entropic inequality testing genuine tripartite nonlocality in quantum systems of arbitrary dimension and also prove the first known monogamy relation for entropic Bell inequalities. Further, within the context of complex Bell networks, we show that entropic nonlocal correlations can be activated.

Q 8.4 Mon 17:45 P 2

**Steering Criteria Based on Tsallis Entropies** — •Ana Cristina Sprotte Costa, Roope Uola, Costantino Budroni, and Otfried Gühne — Universität Siegen, Siegen, Germany

Steering is a term coined by Schrödinger in 1935, within the context of the Einstein-Podolsky-Rosen argument to name Alice's ability in affecting Bob's state through her choice of a measurement basis. Steering has been formalized in terms of a quantum information task involving bipartite states and measurement settings, in which case the existence of entanglement is necessary but not sufficient. Steering inequalities based on entropic uncertainty relations have also been proposed and experimentally tested in the last years. Based on Tsallis entropies, we present a generalization for the entropic steering and its connection with known results from the literature. Special attention will be given for certain families of Tsallis entropies, in order to show that the violation of these generalized steering entropic criteria characterize also the presence of entanglement for bipartite quantum states.

Q 8.5 Mon 18:00 P 2

**On weak values, eigenvalues and expectation values** — •Jan Dziewior[1,2], Alon Ben-Israel[3], Lukas Knips[1,2], Mira Weissl[1,2], Ran Ber[3], Jasmin Meinecke[1,2], Christian Schwemmer[1,2], Lev Vaidman[3], and Harald Weinfurter[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany — [2]Departement für Physik, Ludwig-Maximilians-Universität, 80797 München, Germany — [3]Raymond and Beverly Sackler School of Physics and Astronomy, Tel-Aviv University, Tel-Aviv 69978, Israel

Weak values, which have been introduced in 1988 by Aharonov, Albert and Vaidman, to this day constitute a controversial element in the debate about the foundations of quantum mechanics. While the usefulness of weak values has been demonstrated in various experimental applications, considerable disagreement prevails about their physical meaning.

Here we study the effects of the interaction between quantum systems and a pointer system in order to measure and evaluate their properties. Both in a theoretical analysis of the concept and in an experiment a fundamental difference between expectation values and weak values becomes apparent. Rather than having the statistical properties of expectation values, the similarity of the weak value to eigenvalues indicates that it is a definite property of pre- and post-selected quantum systems.

Q 8.6 Mon 18:15 P 2

**Symmetries of multi-partite quantum systems** — Markus Grassl[1] and •Robert Zeier[2] — [1]Max-Planck-Institut für die Physik des Lichts, Staudtstraße 2, 91058 Erlangen, Germany — [2]Department Chemie, Technische Universität München, Lichtenbergstraße 4, 85747 Garching, Germany

Multi-partite quantum systems exhibit an intricate structure not explained by properties of their subsystems alone. We study the plethora of emerging symmetries that are invariant under local operations. We enumerate these symmetries by computing Hilbert series and also explore connections to so-called Kronecker coefficients. We particularly focus on the case of three-qubit mixed states. Our work provides the foundation for a better understanding of non-local quantum states.

Q 8.7 Mon 18:30 P 2

**Quantum Source-Channel Codes** — •Fernando Pastawski, Henrik Wilming, and Jens Eisert — Freie Universität Berlin

Approximate quantum error-correcting codes are codes with "soft recovery guarantees" wherein information can be approximately recovered. In this article, we propose a complementary "soft code-spaces" wherein a weighted prior distribution is assumed over the possible logical input states. The performance for protecting information from noise is then evaluated in terms of entanglement fidelity. We apply a recent construction for approximate recovery maps, which come with a guaranteed lower-bounds on the decoding performance. These lower bound are straightforwardly obtained by evaluating entropies on marginals of the mixed state which represents the "soft code-space". As an example, we consider thermal states of the transverse field Ising model at criticality and provide numerical evidence that the entanglement fidelity admits non-trivial recoverability from local errors. This provides the first concrete interpretation of a bonafide conformal field theory as a quantum error-correcting code. We further suggest, that quantum source-channel codes could provide a framework to interpret the information structure of holography.

Q 8.8 Mon 18:45 P 2

**Code properties from holographic geometries** — •Fernando

Pastawski[1] and John Preskill[2] — [1]Freie Universität Berlin — [2]California Institute of Technology

Almheiri, Dong, and Harlow proposed a highly illuminating connection between the AdS/CFT holographic correspondence and operator algebra quantum error correction (OAQEC). Here we explore this connection further. We derive some general results about OAQEC, as well as results that apply specifically to quantum codes which admit a holographic interpretation. We introduce a new quantity called price, which characterizes the support of a protected logical system, and find constraints on the price and the distance for logical subalgebras of quantum codes. We show that holographic codes defined on bulk manifolds with asymptotically negative curvature exhibit uberholography, meaning that a bulk logical algebra can be supported on a boundary region with a fractal structure. We argue that, for holographic codes defined on bulk manifolds with asymptotically flat or positive curvature, the boundary physics must be highly nonlocal, an observation with potential implications for black holes and for quantum gravity in AdS space at distance scales small compared to the AdS curvature radius.