Q 26: Quantum Information: Concepts and Methods IV

Time: Tuesday 14:30–16:30 Location: K/HS1

Q 26.1 Tue 14:30 K/HS1

Quantum Computing in Plato's Cave — •Daniel Burgarth[1], Paolo Facchi[2], Vittorio Giovannetti[3], Hiromichi Nakazato[4], Saverio Pascazio[2], and Kazuya Yuasa[4] — [1]Aberystwyth University — [2]Bari University — [3]SNS Pisa — [4]Waseda University

We show that mere observation of a quantum system can turn its dynamics from a very simple one into a universal quantum computation. This effect, which occurs if the system is regularly observed at short time intervals, can be rephrased as a modern version of Plato's Cave allegory. More precisely, while in the original version of the myth, the reality perceived within the Cave is described by the projected shadows of some more fundamental dynamics which is intrinsically more complex, we found that in the quantum world the situation changes drastically as the 'projected' reality perceived through sequences of measurements can be more complex than the one that originated it. After discussing examples we go on to show that this effect is generally to be expected: almost any quantum dynamics will become universal once 'observed' as outlined above. Conversely, we show that any complex quantum dynamics can be 'purified' into a simpler one in larger dimensions.

Q 26.2 Tue 14:45 K/HS1

The resource theory of steering — •Rodrigo Gallego and Leandro Aolita — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany

We present an operational framework for Einstein-Podolsky-Rosen steering as a physical resource. To begin with, we characterize the set of steering non-increasing operations (SNIOs) –i.e., those that do not create steering– on arbitrary-dimensional bipartite systems composed of a quantum subsystem and a black-box device. Next, we introduce the notion of convex steering monotones as the fundamental axiomatic quantifiers of steering. As a convenient example thereof, we present the relative entropy of steering. In addition, we prove that two previously proposed quantifiers, the steerable weight and the robustness of steering, are also convex steering monotones. To end up with, for minimal-dimensional systems, we establish, on the one hand, necessary and sufficient conditions for pure-state steering conversions under stochastic SNIOs and prove, on the other hand, the non-existence of steering bits, i.e., measure-independent maximally steerable states from which all states can be obtained by means of the free operations. Our findings reveal unexpected aspects of steering and lay foundations for further resource-theory approaches, with potential implications in Bell non-locality.

Q 26.3 Tue 15:00 K/HS1

Towards quantum cybernetics — •Rebecca Schmidt and Gerardo Adesso — School of Mathematical Sciences, University of Nottingham, University Park, Nottingham, NG7 2RD, UK

For reliable quantum devices, effective regulation of open quantum systems is vital. In particular, a profound understanding of the interplay between the environment and the regulation is crucial. In this context, it has been shown, that environment and regulation need not to be antagonistic, but their interaction exhibits cooperative effects. To examine the underlying principles of (self-) regulation in open quantum systems, we reformulate the regulation process in terms of quantum information theory. We investigate the role quantum correlations play in this setting. This also addresses the question, how quantum correlations can be exploited to reach the thermodynamic limits of regulation.

Q 26.4 Tue 15:15 K/HS1

Entanglement and correlations in a quantum phase transition — •Andreas Osterloh and Ralf Schützhold — Universität Duisburg-Essen, Duisburg, Germany.

We study the quantum phase transition in the one-dimensional XY model with transverse field. By means of several measures, we study the general qualitative behaviour of multi-partite correlations and entanglement when going from the paramagnetic state with no entanglement to the ferromagnetic phase with purely n-partite (GHZ-type) entanglement.

Q 26.5 Tue 15:30 K/HS1

Verifying the metrological usefulness of Dicke states with collective measurements — •Iagoba Apellaniz[1], Bernd Lücke[2], Carsten Klempt[2], and Géza Tóth[1,3,4] — [1]Department of Theoretical Physics, University of the Basque Country UPV/EHU, P.O. Box 644, E-48080 Bilbao, Spain — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, D-30167 Hannover, Germany — [3]IKERBASQUE, Basque Foundation for Science, E-48013 Bilbao, Spain — [4]Wigner Research Centre for Physics, Hungarian Academy of Sciences, P.O. Box 49, H-1525 Budapest, Hungary

We present a method that can verify the metrological usefulness of noisy Dicke states with few collective measurements. Our method proves the usefulness of the state for estimating the angle of rotation when the Dicke state is in a homogenous magnetic field.

We assume that after the rotation a collective operator is measured to estimate the angle, which is the most relevant case in practice for many-particle systems. We apply our method to recent experimental results with Dicke states.

Q 26.6 Tue 15:45 K/HS1

Generalized spin squeezing in the vicinity of Dicke states — •Giuseppe Vitagliano[1], Iagoba Apellaniz[1], Iñigo Egusquiza[1], Geza Toth[1,2,3], Bernd Lucke[4], Jan Peise[4], and Carsten Klempt[4] — [1]Theoretical Physics, University of the Basque Country UPV/EHU, E-48080 Bilbao, Spain — [2]IKERBASQUE, Basque Foundation for Science, E-48011 Bilbao, Spain — [3]Wigner Research Centre for Physics, H-1525 Budapest, Hungary — [4]Institut fur Quantenoptik, Leibniz Universitat Hannover, Welfengarten 1, D-30167 Hannover, Germany

We study the problem of detecting entanglement and its depth in systems composed of very many particles. We derive entanglement criteria based only on few easy measurable quantities such as the mean values and variances of collective spin components. In particular we present what we call a generalized spin squeezing parameter, that can be used to detect a class of states wider than the spin squeezed states as defined in [A. Sorensen et al., Nature 409, 63 (2001)]. Moreover we present a criterion to estimate the entanglement depth that outperforms previous well-known criteria. It has been used in a recent experiment [B. Lucke et al., PRL 112, 155304 (Editor's suggestion)] to prove that the produced Dicke-like state had an entanglement depth of at least 28 particles.

Q 26.7 Tue 16:00 K/HS1

Entanglement of weighted hypergraph states — •Frank Steinhoff and Otfried Gühne — Universität Siegen, Walter-Flex-Straße 3, D-57068, Siegen, Germany

Recently the properties of so called hypergraph states were studied in detail [1], enabling a full classification of the equivalence under local unitary operations up to four qubits and the construction of new locality/non-contextuality inequalities. In this work we extend some of these results to the more general class of weighted hypergraph states, also known as LME states [2], obtaining new equivalences beyond the Pauli group action. Moreover, it is shown how to create weighted N qubit hypergraphs from N+1 qubit standard hypergraphs by SLOCC.

[1] O. Gühne, M. Cuquet, F.E.S. Steinhoff, T. Moroder, M. Rossi, D. Bruss, B. Kraus, C. Machiavello, J. Phys. A: Math. Theor. 47, 335303 (2014).

[2] C. Kruszynska, B. Kraus, Phys. Rev. A 79, 052304 (2009).

Q 26.8 Tue 16:15 K/HS1

X-chains in Graph States and their Applications — •Junyi Wu, Hermann Kampermann, and Dagmar Bruss — Institut für Theoretische Physik III, HHU Düsseldorf

A special configuration of graph state stabilizers, which contains only Pauli σ_x operators, is studied. Vertex sets ξ associated with such configurations are defined as X-chains of graph states. With the help of X-chain group $\mathcal{X}^{\emptyset}$ of a given graph state $|G\rangle$, one obtains the $\mathcal{X}^{\emptyset}$-factorized group. From these considerations, one obtains the explicit representation of graph states in the rotated X-basis. This representation helps us to understand the graph states in more detail, since it can be employed in various analyses of graph states, e.g. overlaps of graph states and their entanglement. An efficient algorithm is also given for searching X-chains of a graph state.