Q 16: Quantum Information: Concepts and Methods III

Time: Tuesday 11:00–12:45 Location: P 2

Q 16.1 Tue 11:00 P 2

Witnessing Quantum Squeezing via Binary Homodyne Detection — Christian R. Müller[1,2], •Kaushik Seshadreesan[1,2], Gerd Leuchs[1,2], and Christoph Marquardt[1,2] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany. — [2]Department of Physics, University of Erlangen-Nuremberg (FAU), Germany.

Ideal homodyne detection provides an observable with a continuous spectrum. In practical situations, however, the observed quantity is always discretized to some extent. This may be due to the specifics of the protocol, such as the discretization of phase space in CV-QKD, or also due to the limited resolution of the implemented analog-to-digital converter. We consider the extreme case of homodyne detection with a resolution of only 1 bit, i.e., where only the sign of the projected quadrature value is accessible. We illustrate the capacity of such a restricted homodyne detector by demonstrating that even extremely weak squeezing of coherent states can be witnessed. We derive the associated error probabilities in discriminating a coherent state from a weakly squeezed state and experimentally validate our findings. Furthermore, we discuss the possibility of detecting squeezed light transmitted in satellite communication with binary homodyne detectors.

Q 16.2 Tue 11:15 P 2

Quantum Cloning of Binary Coherent States - Optimal Transformations and Practical Limits — •Christian R. Müller[1,2,3], Gerd Leuchs[1,2,4], Christoph Marquardt[1,2], and Ulrik L. Andersen[1,2,3] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany. — [2]Department of Physics, University of Erlangen-Nuremberg (FAU), Germany. — [3]Department of Physics, Technical University of Denmark, Lyngby, Denmark — [4]Department of Physics and Max Planck - University of Ottawa Centre for Extreme and Quantum Photonics, University of Ottawa, Canada

The notions of qubits and coherent states correspond to different physical systems and are described by specific formalisms. Qubits are associated with a twodimensional Hilbert space and can be illustrated on the Bloch sphere. In contrast, the underlying Hilbert space of coherent states is infinite-dimensional and the states are typically represented in phase space. For the particular case of binary coherent state alphabets these otherwise distinct formalisms can equally be applied. We capitalize this formal connection to analyse the properties of optimally cloned binary coherent states. Several practical and near-optimal cloning schemes are discussed and the associated fidelities are compared to the performance of the optimal cloner.

[1] C. R. Müller et al., arXiv:1609.02136v1 [quant-ph]

Q 16.3 Tue 11:30 P 2

Approximating local observables on projected entangled pair states — •Martin Schwarz, Oliver Buerschaper, and Jens Eisert — FU Berlin, Berlin

Tensor network states are for good reasons believed to capture ground states of gapped local Hamiltonians arising in the condensed matter context, states which are in turn expected to satisfy an entanglement area law. However, the computational hardness of contracting projected entangled pair states in two and higher dimensional systems is often seen as a significant obstacle when devising higher-dimensional variants of the density-matrix renormalisation group method. In this work, we show that for those projected entangled pair states that are expected to provide good approximations of such ground states of local Hamiltonians, one can compute local expectation values in quasi-polynomial time. We therefore provide a complexity-theoretic justification of why state-of-the-art numerical tools work so well in practice. We comment on how the transfer operators of such projected entangled pair states have a gap and discuss notions of local topological quantum order. We finally turn to the computation of local expectation values on quantum computers, providing a meaningful application for a small-scale quantum computer.

Q 16.4 Tue 11:45 P 2

Implications of (quasi)extremal local information for the many-body wave function — •Carlos L. Benavides-Riveros[1], Christian Schilling[2], and Peter Vrana[3] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06120 Halle, Germany — [2]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom — [3]Department of Geometry, Budapest University of Technology and Economics, Egry József u. 1., 1111 Budapest, Hungary

The possible compatibility of given density matrices for single site subsystems of a multipartite quantum system is described by linear constraints on their respective spectra. Whenever some of those quantum marginal constraints are saturated, the total quantum state has a specific, simplified structure. We prove that these remarkable global implications of extremal local information are stable, i.e. they hold approximately for spectra close to the boundary of the allowed region. Application of this general result to fermionic quantum systems allows us to propose natural extensions of the Hartree-Fock and Kohn-Sham ansätze based on the corresponding generalized Pauli constraints. This "Mulitionconfigurational Self-Consistent Field"-ansatz is tested for a simple model allowing us to reconstruct about 99.5% of the correlation energy.

Q 16.5 Tue 12:00 P 2

Influence of the Fermionic Exchange Symmetry beyond Pauli's Exclusion Principle — Felix Tennie[1], Vlatko Vedral[1,2], and •Christian Schilling[1] — [1]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom — [2]Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543

Pauli's exclusion principle has a strong impact on the properties and the behavior of most fermionic quantum systems in both, the micro and macro world. Remarkably, a recent mathematical breakthrough has revealed the existence of further constraints on the one-particle picture emerging from the fermionic exchange symmetry. By exploiting those generalized Pauli constraints we develop a measure which allows one to quantify the influence of the exchange symmetry beyond Pauli's exclusion principle. It is based on a geometric hierarchy of Pauli exclusion principle constraints. We provide a proof of principle by applying our measure to a simple model. The corresponding findings conclusively confirm the physical relevance of the generalized Pauli constraints and show that the fermionic exchange symmetry can have an influence on the one-particle picture beyond Pauli's exclusion principle.

Q 16.6 Tue 12:15 P 2

Physical Relevance of Generalized Pauli constraints — •Felix Tennie[1], Daniel Ebler[2], Vlatko Vedral[1,3], and Christian Schilling[1] — [1]Clarendon Laboratory, University of Oxford, Parks Road, Oxford OX1 3PU, United Kingdom — [2]Department of Computer Science, The University of Hong Kong, Pokfulam Road, Hong Kong — [3]Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543

The fermionic exchange symmetry does not only imply Pauli's exclusion principle but even further constraints on fermionic occupation numbers. For concrete systems, these generalized Pauli constraints are particularly relevant whenever they are (approximately) saturated. In the form of a comprehensive analysis of an analytically solvable model (Harmonium) we explore the occurrence of such (quasi)pinning. By analyzing the strength of quasipinning as function of the particle number, coupling strength, spatial dimension and degree of spin polarization we reveal the mechanism behind it. It is the conflict of energy minimization and fermionic exchange symmetry. Consequently, our results suggest the existence of a microscopic Pauli pressure which forces the system into an approximate saturation of the generalized Pauli constraints.

[1] C. Schilling, D. Gross, and M. Christandl, PRL 110, 040404 (2013).

[2] F. Tennie, D. Ebler, V. Vedral, and C. Schilling, PRA 93, 042126 (2016).

[3] F. Tennie, V. Vedral, and C. Schilling, PRA 94, 012120 (2016).

Q 16.7 Tue 12:30 P 2

A fermionic de Finetti theorem — •Christian Krumnow, Zoltan Zimboras, and Jens Eisert — Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, Berlin, Germany

Mean field approaches have a long and successful history in capturing essential features of quantum systems. One way of rigorously bounding the error made within a mean field approximation is to apply quantum versions of the de Finetti theorem. Those theorems link the symmetry of a quantum state under the swap of subsystems to vanishing quantum correlations. More concretely, they show in the case of finite dimensional quantum lattice systems that a state which is invariant under the swaps of lattice sites is locally indistinguishable from a convex combination of product states.

We present a fermionic version of the de Finetti theorem. It is shown that a state which is insensitive to swaps of fermionic modes loses most of its antisymmetric character and can locally be captured by a separable state.