

Q 18: Quanteninformation (Verschränkung und Dekohärenz I)

Zeit: Dienstag 10:30–12:45

Raum: 5L

Gruppenbericht

Q 18.1 Di 10:30 5L
An observable entanglement measure — ●FLORIAN MINTERT¹, LEANDRO AOLITA^{2,3}, RAFAL DEMKOWICZ DOBRZANSKI⁴, STEPHEN WALBORN², PAULO SOUTO RIBEIRO², LUIZ DAVIDOVICH², MAREK KUS⁴, and ANDREAS BUCHLEITNER³ — ¹Department of Physics, Harvard University — ²Universidade Federal do Rio de Janeiro — ³Max Planck Institut fuer Physik Komplexer Systeme, Dresden — ⁴Centrum Fizyki Teoretycznej Polskiej Akademii Nauk, Warszawa

Although entanglement constitutes one of the most remarkable differences between classical and quantum mechanics, and it does have directly observable consequences, it is not an observable like for example momentum or energy. Unlike a regular observable that has an associated hermitean operator, an entanglement measure is rather a non-linear functional of a large set of such observables. Therefore, one typically needs to perform many different measurements, in order to determine the degree of entanglement of a given quantum state. We show, how the entanglement measure concurrence is given in terms of collective observables of two identically prepared quantum states. This allows for a direct experimental estimate of the concurrence of arbitrary finite dimensional quantum states as it is demonstrated in a laboratory experiments with pure twin photon states.

Q 18.2 Di 11:00 5L

Experimental detection of SLOCC invariants — ●ANDREAS OSTERLOH¹ and JENS SIEWERT² — ¹Institut für Theoretische Physik, Universität Hannover, D-30167 Hannover, Germany — ²Institut für Theoretische Physik, Universität Regensburg, D-93040 Regensburg, Germany

Characterization and quantification of multipartite entanglement is a crucial task for state-of-the-art experiments in quantum information processing, and also in modern condensed-matter physics. According to theory, this is established by entanglement monotones, that is, functions that do not increase under stochastic local operations and classical communication (SLOCC). However, typically such functions are expressed in terms of expectation values of antilinear operators, and therefore are not directly accessible in an experiment. Here we show how such monotones can be re-written in terms of expectation values of (linear) hermitian operators. That is, the amount of entanglement – of specific SLOCC classes – in a given state can be extracted from the measurement of correlation functions of local operators.

Q 18.3 Di 11:15 5L

Photon-photon entanglement in the 2E1 decay of atomic hydrogen — ●THOMAS RADTKE¹, STEPHAN FRITZSCHE¹, and ANDREY SURZHYKOV² — ¹Institut für Physik, Universität Kassel, D-34132 Kassel, Germany — ²Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

The theory of the two-photon decay of (metastable) hydrogen was developed already in the early days of quantum mechanics. However, only several decades later, it was demonstrated experimentally that the correlation in the polarization states of the two photons indeed violates Bell's inequality so that the photons are entangled [1].

More recently, within the context of quantum information processing, new interest arose in controllable sources of entanglement. Therefore, in this contribution, we have investigated in more detail the photon-photon entanglement in the 2E1 decay of atomic hydrogen. In particular, we study the entanglement as a function of the emission angles of the two photons and (for the case of excited states) the atom's initial spin state. It is found that the two-photon decay of hydrogen may lead to pairs of photons with controllable degree of entanglement as it is used in various quantum information protocols.

[1] Perrie et al., Phys. Rev. Lett. 54, 1790 (1985)

Q 18.4 Di 11:30 5L

Covariance matrices and the separability problem — OTFRIED GÜHNE¹, PHILIPP HYLLUS^{2,3}, ●OLEG GITTSOVICH^{4,1}, and JENS EISERT³ — ¹Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Österreich — ²Institut für Theoretische Physik, Universität Hannover, Appelstrasse 2, 30167 Hannover, Deutschland — ³QOLS, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2BW, UK and Institute for Mathematical Sciences, Imperial Col-

lege London, Prince's Gate, London SW7 2PE, UK — ⁴Institut für Theoretische Physik, Universität Innsbruck, Technikerstrasse 25, 6020 Innsbruck, Österreich

The separability problem deals with a question to decide whether a given state is entangled or separable, which is very important from the point of view of applicability of the quantum information theory. This task belongs to the one of the still unsolved theoretical problems, which has received a significant amount of attention in recent years. In this talk I will present a new unifying approach to the separability problem for finite dimensional systems. Our method uses a representation of a quantum state by a covariance matrix of suitable observables. On the one hand, our approach leads to entanglement criteria that detect all entangled states of two qubits, as well as indeed many bound entangled states and, on the other hand, provides a framework to link and understand several existing criteria like cross-norm (or realignment) criterion, a recent criterion using Bloch representation or the local uncertainty relations.

Q 18.5 Di 11:45 5L

Do NPT bound entangled states exist? — ●ELISABETH RIEPER and REINHARD WERNER — Institut für Mathematische Physik, TU Braunschweig, www.imaph.tu-bs.de

The existence of NPT bound entangled states is equivalent to the existence of NPT Bound Werner states. A current conjecture is that 1-copy undistillable Werner states remain undistillable even for many copies. This would provide a large set of NPT bound entangled states. We investigate the distillation properties of these states with a new distillation protocol. We check for the maximal achievable fidelity of the output state by solving a generalized eigenvalue problem. By exploiting the symmetries of Werner states we find a new contraction scheme avoiding high dimensional matrices. This scheme enables us to test distillability of up to four copies. The numerical results for 1 to 4 copies support the above conjecture that undistillable Werner states are already 1-copy undistillable.

Q 18.6 Di 12:00 5L

talk "statistic dependence of the entanglement entropy" moved to 12:30 — ●XXX XXX — xxx

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Q 18.7 Di 12:15 5L

Full experimental characterization of Gaussian entangled states — ●JAMES DIGUGLIELMO, BORIS HAGE, ALEXANDER FRANZEN und ROMAN SCHNABEL — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Institut für Gravitationsphysik, Leibniz Universität Hannover, Callinstr. 38, 30167 Hannover

A quantitative characterization of quantum information communication channels by means of quantities such as the von Neumann entropy and quantum capacity require the full knowledge of the entangled EPR state being used to establish the channel. For Gaussian states, this can be achieved by measuring the covariance matrix. To this end we present an experimental procedure for the measurement of the entire covariance matrix using as few measurements as possible. We apply this method to the characterization of three different types of EPR states and then use the reconstructed matrices to obtain the lower bound to the quantum channel capacity as well as other information theoretic quantities such as the partial information. The purity and logarithmic negativity are calculated as well.

Q 18.8 Di 12:30 5L

Statistics dependence of the entanglement entropy — ●MARCUS CRAMER¹, JENS EISERT^{2,3}, and MARTIN PLENIO^{2,3} — ¹Institut für Physik, Universität Potsdam, Am Neuen Palais 10, D-14469 Potsdam, Germany — ²QOLS, Blackett Laboratory, Imperial College London, Exhibition Road, London, SW7 2BW, UK — ³Institute for Mathematical Sciences, Imperial College London, Exhibition Road, London, SW7 2BW, UK

The entanglement entropy of a distinguished region of a quantum many-body problem reflects the entanglement present in its pure ground state. In this work, we establish scaling laws for the entanglement entropy for critical quasi-free fermionic and bosonic lattice

systems, without resorting to numerical means. We consider the geometrical setting of D -dimensional half-spaces. Intriguingly, we find a difference in the scaling properties depending on whether the system is bosonic—where an area-law is first proven to hold—or fermionic, extending previous findings for cubic regions. For bosonic systems with nearest neighbor interaction we prove the conjectured area-law by com-

puting the logarithmic negativity analytically. For fermions we determine the multiplicative logarithmic correction to the area-law, which depends on the topology of the Fermi surface. We find that Lifshitz quantum phase transitions are accompanied with a non-analyticity in the prefactor of the leading order term.