Q 67: Quanteneffekte: Verschränkung und Dekohärenz 2

Time: Friday 14:00–16:00 Location: V7.01

Q 67.1 Fri 14:00 V7.01

Decoherence and the Nature of System-Environment Correlations — •Ansgar Pernice and Walter T. Strunz — Institut für Theoretische Physik, Technische Universität Dresden, D-01062 Dresden, Germany

We investigate system-environment correlations based on the exact dynamics of a qubit and its environment in the framework of pure decoherence (phase damping). We focus on the relation of decoherence and the build-up of system-reservoir entanglement for an arbitrary (possibly mixed) initial qubit state. In the commonly employed regime where the qubit dynamics can be described by a Markov master equation of Lindblad type, we find that for almost all qubit initial states inside the Bloch sphere, decoherence is complete while the total state is still separable - no entanglement is involved. In general, both "separable" and "entangling" decoherence occurs, depending on temperature and initial qubit state. Moreover, we find situations where classical and quantum correlations periodically alternate as a function of time in the regime of low temperatures.

Q 67.2 Fri 14:15 V7.01

A macroscopicity measure from a minimal modification of quantum time evolution — •Stefan Nimmrichter[1] and Klaus Hornberger[2] — [1]University of Vienna, Vienna Center for Quantum Science and Technology (VCQ), Boltzmanngasse 5, 1090 Vienna, Austria — [2]University of Duisburg-Essen, Faculty of Physics, Lotharstraße 1, 47048 Duisburg, Germany

We formulate an experimentally accessible measure for the degree of macroscopicity of quantum states. It is based on a minimally invasive modification of the quantum time evolution, which is still compatible with basic principles such as conservation of probabilities, Galileian covariance, particle exchange symmetry and scale invariance. This way different quantum experiments can be compared by assessing the extent to which they exclude such a modification.

Q 67.3 Fri 14:30 V7.01

Optimal Control of open quantum systems: Cooperative effects of driving and dissipation — •Rebecca Schmidt, Jürgen T. Stockburger, and Joachim Ankerhold — Institut für Theoretische Physik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm

We formulate a consistent approach for the optimal control of open quantum systems [1]. In particular, the mutual influence of driving and dissipation is investigated. Therefore we combine optimal control techniques with an exact description of the non-Markovian open system dynamics by means of stochastic Liouville-von Neumann equations [2]. The application to a harmonic degree of freedom reveals cooperative effects of driving and dissipation. Extension of our work to entangled states exposed to dissipation is discussed.

[1] R. Schmidt, A. Negretti, J. Ankerhold, T. Calarco and J.T. Stockburger, Phys.Rev.Lett. **107**, 130404 (2011)

[2] J.T. Stockburger and H. Grabert, Phys.Rev.Lett. **88**, 170407 (2002)

Q 67.4 Fri 14:45 V7.01

Efficient Simulation of System-Environment Interactions at Finite Temperatures — •Robert Rosenbach[1], Javier Prior[2], Alex W. Chin[3], Susana F. Huelga[1], and Martin B. Plenio[1] — [1]Institut für Theoretische Physik, Universität Ulm — [2]Escuela de Arquitectura e Ingeniería de Edificación, Universidad Politécnica de Cartagena — [3]Theory of Condensed Matter Group, Cavendish Laboratory, Cambridge

Multi-component quantum systems strongly interacting with an environment lie at the core of various physical problems, as for example in the quantum biology. Difficulties in the treatment of those systems have recently been overcome by introducing a transformation of the environment, thus making the problem accessible to DMRG-like algorithms.

In this talk I will present this method, extended to mixed states, now allowing the simulation of such systems at realistic conditions. Obtained results for the time evolution of a dimer coupled to a thermal bath are used to assess the capabilities of the method.

Q 67.5 Fri 15:00 V7.01

A Hierarchy of Entanglement — •Federico Levi and Florian Mintert — Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs-Universität Freiburg, Albertstr. 19, 79104 Freiburg

We construct a hierarchy of criteria that identifies the different degrees of entanglement within mixed, N-partite systems. The K-th element in the hierarchy is positive for states with at least K-body entanglement, so that the hierarchy provides a detailed characterisation of many-body entanglement ranging from bipartite to genuine N-body entanglement. As we show, the different degrees of entanglement detected by the different elements in the hierarchy are also reflected in different dynamical behaviour as the system undergoes coherent or incoherent evolution.

Q 67.6 Fri 15:15 V7.01

Energetic consequences of pure decoherence — •C. Aris Dreismann[1], Evan MacA. Gray[2,3], and Tom P. Blach[2,3] — [1]Institute of Chemistry, TU Berlin — [2]Griffith University, Brisbane, Australia — [3]Queensland Micro- and Nanotechnology Centre, Australia

We consider the dynamics of open quantum systems exhibiting pure decoherence (i.e. without dissipation), e.g. the well known master equations of the so-called Lindblad form. They ensure positivity of the system's reduced density operator, but they also exhibit a distrurbing feature: an intrinsic increase of the system's energy [1]. This effect of decoherence has been theoretically shown [2,3] to be of rather general character, under the condition that the characteristic time of the process is sufficient short. Here we report first experimental evidence of this surprising effect, in the frame of attosecond neutron Compton scattering (NCS) from protons and deuterons (of H2 and D2) [4]. We also propose a qualitative theoretical understanding of the experimental results [4]. The observations stand in blatant contradiction to conventional theory of neutron scatering, in which decoherence (and, more general, a non-unitary evolution) plays no role.

[1] L. E. Ballentine, Phys. Rev. A 43 (1991) 9. [2] L. S. Schulman and B. Gaveau, Phys. Rev. Lett. 97 (2006) 240405. [3] N. Erez et al. Nature 452 (2008) 724. [4] C. A. Chatzidimitriou-Dreismann, E. MacA. Gray and T. P. Blach, AIP Advances 1 (2011) 022118.

Q 67.7 Fri 15:30 V7.01

Arvesons Entanglement Measure in Finite Dimensional Quantum Systems — •Florian Sokoli and Gernot Alber — Institut für angewandte Physik, Theoretical Quantum Physics Group, Technische Universität Darmstadt

The problem of understanding entanglement is crucial for quantum information theory and applications. However, entanglement is poorly understood at least for multipartite and mixed quantum states. In 2008, the mathematician William Arveson [1] proposed a powerful and elegant way of quantifying entanglement which applies to arbitrary N-partite quantum states and reduces to the so called "projective norm" of density operators in finite dimensional systems. However, in general its computation is difficult. We propose a new technic which can be interpreted as a generalized Schmidt decomposition for multipartite systems. With its help the computation of the projective norm of a large class of quantum states can be reduced to the determination of eigenvalues. These so called gsd-states are characterized by having support on certain subspaces of the underlying Hilbert space. In particular, mixed states are included and this class of states is stable under mixing. We derive a formula for the quantification of the amount of entanglement for multipartite states that arise by tracing out arbitrary subsystems of a special type of gsd-states. [1] William Arveson, arXiv:0804.1140v5

Q 67.8 Fri 15:45 V7.01

Robust entanglement production based on Rubin's one-dimensional crystal — •Endre Kajari[1], Alexander Wolf[1], Eric Lutz[2,3], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany — [2]Department of Physics, University of Augsburg, D-86135 Augsburg, Germany — [3]Institut für Theoretische Physik, Freie Universität Berlin, D-14195 Berlin, Germany

Rubin's model provides a microscopic description for the dynamics of thermalization of a defect particle embedded in a one-dimensional crystal [1]. Under certain conditions, the crystal acts as a reservoir and pulls the defect into a thermal state at the temperature of the harmonic chain. In a recent paper [2], we showed how a reservoir like the one of Rubin can support the creation of entanglement between two defects (even when it acts as thermal reservoir for a single defect). In this talk, we give a detailed discussion of the conditions that have to be met for the generation of this steady-state entanglement. In particular, we identify two mechanisms that give rise to entanglement. We quantify the steady-state entanglement by means of the logarithmic negativity and examine in detail its dependence on the initial states of the defects and the reservoir, as well as on the parameters of the underlying microscopic model.

[1] R. J. Rubin, Phys. Rev. **131**, 964 (1963).
[2] A. Wolf, G. de Chiara, E. Kajari, E. Lutz and G. Morigi, EPL **95**, 60008 (2011).