Q 25: Quantum effects: Entanglement and decoherence II

Time: Tuesday 14:00–15:45 Location: DO24 1.101

Q 25.1 Tue 14:00 DO24 1.101

Propagation of Orbital Angular Momentum Photons through Atmospheric Turbulence — •Nina Leonhard, Vyacheslav Shatokhin, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder Str. 3, 79104 Freiburg, Germany

Quantum information can be encoded into the wave fronts of photons carrying orbital angular momentum (OAM), where the Hilbert space is, in principle, of arbitrary dimension. As such, photons with OAM are very promising for free-space quantum communication. However, free-space links are intrinsically noisy due to atmospheric turbulence, causing distortion of the photon's wave front and deterioration of quantum information. In this talk, we will discuss the impact of atmospheric turbulence on the bipartite entanglement of photonic OAM qudits using the phase screen model. In particular, we show that the entanglement of qubits ($d = 2$), qutrits ($d = 3$) and ququarts ($d = 4$) vanishes at moderate values of the turbulence strength. Furthermore, we identify entangled states that are most robust against atmospheric turbulence. We show that with increasing turbulence strength, high-dimensional OAM states become rather fragile, and the maximally entangled effective qubits turn out to be the most robust states.

Q 25.2 Tue 14:15 DO24 1.101

A map for finding hidden quantum Markovian models — •Michael R. Hush, Igor Lesanovsky, and Juan P. Garrahan — University of Nottingham, Nottingham, NG7 2RD, UK

The aptly named master equation (ME) reigns over the analysis of open quantum systems. The Lindblad form - it is required to have - guarantees a density matrix that obeys it will always have a probabilistic (physical) interpretation. However many applications in nonequilibrium systems produce master equations that are not in Lindblad form, (NLME).

We solve this problem, by providing a framework to map NLME to a ME by the addition of an ancillary system. We demonstrate that the ancilla only need be a two level system.

We apply our result to two cases. We provide a way to physically access the dynamical large-deviation regime of open quantum systems, hopefully paving the way for experimental exploration of dynamical phase transition behaviour that has been predicted by theory.

Second we are able to prove a no-tracking theorem which states that given a quantum system undergoing a weak measurement it is impossible to track this system with a quantum system of the same size (even with the addition of an ancilla). This result has implications on what is achievable with regard to tracking, and quantum control in general.

Preprint available at: arXiv:1311.7394.

Q 25.3 Tue 14:30 DO24 1.101

Theory of Decoherence of Electron Waves - Visualizing the Quantum-Classical Transition — •Regine Frank — Institute for Theoretical Physics, Eberhard-Karls University Tübingen, Germany Center for Light-Matter-Interaction, Sensors and Analytics (LISA+) and Center for Complex Quantum Phenomena (CQ)

Controlled decoherence of free electrons due to Coulomb interaction with a truly macroscopic environment, a semiconducting plate, is studied theoretically using open quantum dynamics. The quantitative theoretical results are compared with experimental data. The comparison of theory and experiment confirms the main features of the theory of decoherence and can be interpreted in terms of which-path information which visualize the transition from quantum to classical.

P.Sonnentag and F.Hasselbach PRL 98, 200402 (2007)

Q 25.4 Tue 14:45 DO24 1.101

On the structure of the exact master equation — •Ines de Vega — Department of Physics and Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-University Munich, Theresienstr. 37, 80333 Munich, Germany

In the past decades, there has been an increasing interest in analyzing the dynamics of quantum open systems (QOS) coupled to an environment. Much effort has been devoted to the derivation of master equations that describe the dynamics of the reduced density matrix of the system. Whereas different master equations have been derived within the so-called weak coupling approximation (assuming that the coupling between the system and the environment is small compared to other energy scales of the problem), or with projection operator techniques (i.e. generating a projection over what is assumed to be the 'relevant' part of the Hilbert space), a derivation of a master equation beyond such approximations or assumptions has been more elusive. In this work, we derive a master equation from the exact Liouville von-Neumann (SLN) equation (Stockburger (2002)). This last equation depends on two correlated noises and describes exacty the dynamics of an oscillator (that can be both harmonic or anharmonic) coupled to an environment in thermal equilibrium. The newly derived master equation should therefore recover the same results as the original von-Neumann equation but without the convergency problems derived from having to make the stochastic average of two noises.

Q 25.5 Tue 15:00 DO24 1.101

Quantum Mutual Information of an Entangled State Propagating through a Fast-Light Medium — •Ulrich Vogl[1], Jeremy Clark[2], Ryan Glasser[2], Quentin Glorieux[2], Tian Li[2], and Paul Lett[2] — [1]Max Planck Institute for the Science of Light, Günther-Scharowsky-Straße 1, Bau 24, 91058 Erlangen, Germany. — [2]2National Institute of Standards and Technology and Joint Quantum Institute, 100 Bureau Dr., Gaithersburg, MD 20899-8424

Quantum states of light have been shown to provide improvements in a variety of systems, resulting in better imaging, sub-shot noise interferometry, and computation schemes. A key aspect of these entangled and squeezed states of light is that they exhibit correlations that are stronger than allowed classically. Due to the important role entanglement plays in the field of quantum optics, numerous investigations into its fundamental behavior have taken place. Experiments investigating how entanglement evolves when propagating through a slow light medium, in which the group velocity of light is less than the speed of light in vacuum, c, have been conducted in the past. Here, we seek to investigate how quantum correlations and entanglement behave when propagating through a medium exhibiting anomalous dispersion. In such a medium, optical pulses may propagate with group velocities that are larger than c, or even negative. We demonstrate that the dispersion associated with non-degenerate four-wave mixing process in warm rubidium vapor may be used to generate pulses with record negative group velocities. Additionally, we will discuss recent results involving the combination of fast light and quantum entanglement.

Q 25.6 Tue 15:15 DO24 1.101

Stabilizing Open Systems via Continuous Monitoring — •Tobias Brünner, Clemens Gneiting, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

The screening of quantum properties such as coherence and entanglement against detrimental environmental noise is a key issue in quantum technologies. While coherent control techniques are now well-established, it has been shown that they can stabilize only a limited degree of coherence. We investigate to what extent continuous monitoring and unitary feedback can enhance the desired quantum properties. To this end, we monitor single qubit quantum trajectories in the presence of spontaneous decay. We find that - in contrast to unmonitored systems - arbitrary pure states can be stabilized.

Q 25.7 Tue 15:30 DO24 1.101

Optimal control strategy for long distance entanglement in disordered spin chain — •Jian Cui[1,2] and Florian Mintert[1,2] — [1]FRIAS, Albert Ludwigs University of Freiburg, Albertstr. 19, 79104 Freiburg, Germany — [2]Department of Physics, Imperial College London, SW7 2AZ, United Kingdom

We derive temporally shaped control pulses for the creation of long-distance entanglement in disordered spin chains. Our approach is based on a time-dependent target functional and a time-local control strategy that permit to ensure that the description of the chain in terms of matrix product states (MPS) is always valid. With this approach, we demonstrate that long-distance entanglement can be created and maintained even for substantially disordered interaction landscapes.