Q 11: Quantum effects: Entanglement and decoherence I

Time: Monday 14:00–15:45 Location: DO24 Reuter Saal

Q 11.1 Mon 14:00 DO24 Reuter Saal

Adiabatic control of electron and nuclear spins in diamond — •Samuel Wagner[1], Florian Dolde[1], Christian Burk[1], Philipp Neumann[1], Carlos Meriles[2], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut und SCoPE Research Center, Universität Stuttgart — [2]Department of Physics, The City College of New York

The NV center in diamond is one of the most prominent examples for a central spin system, where the electron spin of the NV center is influenced by its hyperfine interaction with a bath of surrounding ^{13}C nuclear spins and vice versa. With the ability of optical spin read out and polarization of the electron spin and coherence times of a few hundred μs at room temperature the NV is an easy accessible model system. The decoherence properties of the NV electron spin is governed by the nuclear spin bath.

In this work we will investigate the adiabatic control of the nuclear spin bath and the central electron spin to tailor the mutual interaction Hamiltonian. The latter will then affect the dynamics and coherence properties of the NV center electron spin.

Q 11.2 Mon 14:15 DO24 Reuter Saal

Phenomenological non-Markovian dynamics of open quantum systems — •Björn Witt, Łukasz Rudnick, and Florian Mintert — Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs-Universität Freiburg, Albertstr. 19, 79104 Freiburg

Truncated hierarchical equations of motions (HEOM) [1] define an efficient framework for the description of non-Markovian open quantum dynamics. We investigate to what extent this approach is suitable for a phenomenological description. We strive to identify necessary and/or sufficient conditions, such that the induced dynamical map is completely positive and trace-preserving. For this purpose we consider low-dimensional systems and the classical analogue of the HEOM for which we demonstrate how such conditions can be inferred.

[1] A. Ishizaki and Y. Tanimura, J. Phys. Soc. Jpn. **74**, 3131 (2005)

Q 11.3 Mon 14:30 DO24 Reuter Saal

Quantum Darwinism and the Appearance of Classicality: A model based on Random Unitary Operations (RUO) — •Nenad Balaneskovic[1], Gernot Alber[1], and Jaroslav Novotny[1,2] — [1]Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany — [2]Department of Physics, FNSPE, Czech Technical University in Prague, 115 19 Praha 1 - Stare Mesto, Czech Republic

We discuss characteristic properties of pure decoherence and Quantum Darwinism (QD) [1] based on qubit-models of open systems interacting with their respective environment by iterated and randomly applied controlled-NOT-type operations [2]. From the analytically determined asymptotic dynamics of the resulting quantum Markov chain the QD-appearance of Classicality and its connection to König-digraph interaction (KDI) models [3] of pure decoherence can be investigated. KDI comprise environmental qubits which do not interact among themselves by unitary quantum operations and are thus suitable to physically describe objective quantum measurements performed on an open system by autonomous observers (environmental qubits). KDI model also accounts for the most efficient storage of classical information of a system into its environment. Since the efficiency of the mentioned information storage is also connected with Zurek's concept of QD, we address physical limits of the QD-concept within our RUO approach. [1] W. H. Zurek, Nature Physics 5, 181-188 (2009). [2] Novotny, J., Alber, G., Jex, I., Phys. Rev. Lett. 107, 090501 (2011). [3] Brualdi, R.: "A Combinatorial Approach to Matrix Theory" (T&F, London, 2011).

Q 11.4 Mon 14:45 DO24 Reuter Saal

Tripartite separability conditions exponentially violated by Gaussian states — •Evgeny Shchukin and Peter van Loock — Johannes Gutenberg-Universität Mainz, Germany

We derive a hierarchy of conditions valid for all tripartite biseparable quantum states. Our conditions are expressed as inequalities for special combinations of moments of creation and annihilation operators of arbitrary high order. Violation of any inequality of our hierarchy is a sufficient condition for genuine tripartite entanglement. We give examples of pure Gaussian states that violate all of our conditions simultaneously and the violation grows exponentially with the order of moments. Our approach also allows an extension to the general multipartite case.

Q 11.5 Mon 15:00 DO24 Reuter Saal

Testing Bell-like inequalities in the x-ray regime — •Lida Zhang and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

A setup is proposed to test a Bell-like inequality in the hard x-ray frequency regime. A single x-ray photon is sent through a Mach-Zehnder interferomenter with variable phase shifters in the two arms. Based on a locality assumption, a classical inequality can be derived, which is violated by the predictions of quantum mechanics [1]. We show that our proposal can be implemented with nuclei embedded in a nm-sized thin film cavity probed by x-ray light in grazing incidence. This setup has proven successful in a number of recent experiments on x-ray quantum optics. Our calculations follow a recently established quantum optical framework for the description of this setting [2,3].

[1] H.-W. Lee and J. Kim, Phys. Rev. A 63, 012305 (2000).
[2] K. P. Heeg and J. Evers, Phys. Rev. A 88, 043828 (2013).
[3] K. P. Heeg et. al., Phys. Rev. Lett. 111, 073601 (2013).

Q 11.6 Mon 15:15 DO24 Reuter Saal

Multipartite entanglement evolution in open quantum systems under continuous monitoring — •Carlos Viviescas — Departamento de Física, Universidad Nacional de Colombia, Carrera 30 No.45-03, Bogotá D.C., Colombia

A key lesson of the decoherence program is that information flowing out from an open system is stored in the quantum state of the surroundings. Simultaneously, quantum measurement theory shows that the evolution of any open system when its environment is measured is nonlinear and leads to pure states conditioned on the measurement record. We use this conditional evolution to establish a time evolution equations for the average entanglement in the system, avoiding the, up to now, unescapable step of solving first the evolution of the unconditional state. We show how this equations can be use to extract fundamental relations between entanglement and measurement at the level of single quantum trajectories in systems whose environment is being continuously monitored. Moreover, we show how such monitoring can be use to develop general protocols for entanglement protection using local measurements.

Q 11.7 Mon 15:30 DO24 Reuter Saal

Dissipative preparation of entangled steady states — •Florentin Reiter and Anders S. Sørensen — QUANTOP, The Niels Bohr Institute, University of Copenhagen, Blegdamsvej 17, DK-2100 Copenhagen Ø, Denmark

Quantum information processing is mostly performed by unitary gate operations which suffer from decoherence and dissipation. This imposes strong limitations on the realization of quantum information tasks.

Engineering dissipation to carry out such tasks is considered an alternative way of quantum information processing which may have the potential to overcome the problems with the unitary approach. Previous theoretical studies have shown that dissipation indeed allows for an improvement of entangling operations [1]. More recently, the dissipative preparation of a maximally entangled steady state of two qubits has been demonstrated experimentally in ion traps [2].

We present recent progress towards more general dissipative operations, in particular in the direction of scalable generation of entanglement and improved robustness against noise.

[1] M. J. Kastoryano, F. Reiter, and A. S. Sørensen, Phys. Rev. Lett. 106, 090502 (2011).

[2] Y. Lin, J. P. Gaebler, F. Reiter, T. R. Tan, R. Bowler, A. S. Sørensen, D. Leibfried, and D. J. Wineland, to appear in Nature, doi:10.1038/nature12801.