Q 10: Quantum Information (Concepts and Methods) II

Time: Monday 16:30–17:45 Location: Q-H12

Q 10.1 Mon 16:30 Q-H12

Initial state dependence in the dynamics of open systems — •Sebastian Wenderoth and Michael Thoss — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Intuitively, an open system coupled to an environment relaxes to a well-defined and unique equilibrium state, which is determined by macroscopic properties of the environment like the temperature or the chemical potential only. In the long-time limit, the state of the open system is thus expected to be independent of its initial state.

In this contribution we present a concept which allows us to characterize the influence of the initial state on the dynamics of an open system. Our approach is based on the reduced system propagator, the latter being a linear map on the open system's state space. Using properties of the reduced system propagator we quantify the influence of the initial state on expectation values of observables of the open system. Additionally, we provide necessary and sufficient conditions under which the long-time dynamics of an open system is independent of its initial state. We demonstrate our concepts for different long-time behaviors of the spin-boson model.

Q 10.2 Mon 16:45 Q-H12

Bohmian Trajectories in a Double Slit Experiment — •Carlotta Versmold[1,2,3], Jan Diewior[1,2,3], Lukas Knips[1,2,3], Florian Huber[1,2,3], Jasmin Meinecke[1,2,3], and Harald Weinfurter[1,2,3] — [1]Department für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), Munich, Germany

Bohmian mechanics (BM) is one of many alternative interpretations of quantum mechanics (QM). Attributing a definite position to particles at all times it allows the introduction of particle trajectories, which are forbidden in standard QM. Necessary for this is the introduction of nonlocal effects into the theory, which can cause instantaneous reordering of trajectories. In order to investigate this non-locality one photon of an entangled photon pair is sent through a double slit apparatus where its average Bohmian trajectory is observed via weak measurement. Employing the entanglement in the photon's polarization degree of freedom enables to analyze different cases of which-way-information as the evolution of the interfering photon depends on the observation of the second photon. By varying the point in time of the polarization-measurement of the second photon, delayed choice measurements of the corresponding trajectories can be performed.

Average trajectories have already been measured in experiments and are shown to correspond with those calculated in BM. Nevertheless, the meaning of average trajectories and BM is much discussed. This experiment will contribute to a better understanding of the theory.

Q 10.3 Mon 17:00 Q-H12

Markovian Quantum Systems with Full and Fast Hamiltonian Control — •Emanuel Malvetti[1,2], Frederik vom Ende[1,2], Thomas Schulte-Herbrüggen[1,2], and Gunther Dirr[3] — [1]Dept. Chem., TU-München (TUM) — [2]Munich Centre for Quantum Science and Technology (MCQST) and Munich Quantum Valley (MQV) — [3]Institute of Mathematics, Universität Würzburg

Markovian quantum systems with full and fast Hamiltonian control can be reduced to an equivalent control system on the eigenvalues of the density matrix describing the state. First we consider the case of a single qubit, presenting explicit solutions of the optimal control problem for a large family of Lindblad operators. For the cases where analytic solutions seem out of reach, we can still efficiently compute numerical solutions. Second we consider quantum systems of arbitrary finite dimension. While analytic solutions to optimal control problems do not exist in the general case, the reduced control system on the eigenvalues is still a powerful tool. As an example, we derive necessary and sufficient conditions for a Markovian quantum system to be coolable.

Q 10.4 Mon 17:15 Q-H12

Bohmian Trajectories of Quantum Walks — •Florian Huber[1,2,3], Carlotta Versmold[1,2,3], Jan Dziewior[1,2,3], Lukas Knips[1,2,3], Harald Weinfurter[1,2,3], and Jasmin Meinecke[1,2,3] — [1]Department für Physik, Ludwig-Maximilians-Universität, Munich, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]Munich Center for Quantum Science and Technology (MC-QST), Munich, Germany

Quantum walks are the quantum mechanical equivalent to the classical random walk and ,in standard quantum mechanics (QM), describes the coherent propagation of a quantum particle in a discrete environment, which cannot be represented with trajectories, as it would be possible in the classical case. However, certain interpretations of QM, as for example Bohmian mechanics, a non-local hidden variable theory, attribute definite positions and momenta to particles and therefore allow particle trajectories. In classical electrodynamics energy flow lines of photons, given by the Poynting vectors, correspond to these Bohmian trajectories. Here we report on the simulation and how to observe energy flow lines of a quantum walk, realized in an integrated waveguide array written into fused silica substrate. The curvature of the phase front, corresponding to the Poynting vector is reconstructed via weak measurements. To this end, the curvature is first weakly coupled to the polarization of the photons. Subsequently, a strong polarization measurement, behind a phase front preserving magnification optics, gives the desired information on the phase front curvature and thus makes a reconstruction of the Bohmian trajectories possible.

Q 10.5 Mon 17:30 Q-H12

On Quantum Cats and How to Control Them — •Matthias G. Krauss[1,2], Daniel M. Reich[1,2], and Christiane P. Koch[1,2] — [1]Universität Kassel, Kassel, Germany — [2]Freie Universität, Berlin, Germany

Schrödinger cat states are non-classical superposition states that are useful in quantum information science, for example for computing or sensing. Optimal control theory provides a set of powerful tools for preparing such superposition states, for example in experiments with superconducting qubits [Ofek, et al. *Nature* **536**, 2016]. In general, the preparation of specific cat states is considered to be a hard problem [Kallush et al. *New J. Phys.* **16**, 2014]. Since many applications do not rely on a particular cat state, it can be beneficial to optimize towards arbitrary cat states instead. We derive optimization functionals that target the cat properties without prescribing a specific cat state. To analyze the practical performance of these functionals, we exemplify their use in conjunction with Krotov's method [Reich et al. *J. Chem. Phys.* **136**, 2012]. In particular, we analyze the quantum speed limit for generating entangled cat states in a Jaynes-Cummings model and test their robustness under dissipation.