Q 43: Quantum information: Concepts and methods II

Time: Thursday 14:00–16:00 Location: Kinosaal

Group Report Q 43.1 Thu 14:00 Kinosaal
Understanding the Geometry of Quantum Dynamics and its Control: a Progress Report — •Thomas Schulte-Herbrüggen[1], Ville Bergholm[1,2], Corey O'Meara[1], Robert Zeier[1], Zoltán Zimborás[3], Michael Keyl[4], and Gunther Dirr[5] — [1]Dept. Chem., TU-München (TUM) — [2]ISI Foundation, Torino, Italy — [3]Univ. of Bilbao, Spain — [4]Math. Inst., TU-München (TUM) — [5]Math. Inst., University of Würzburg

Quantum control methods and the underlying systems theory play an increasingly important role in manipulating quantum dynamics and quantum simulation.

We give an overview on recent progress in (1) noise-modulation assisted transfer between arbitrary quantum states, (2) dissipative fixed-point engineering, (3) coherent control in finite- and infinite-dimensional systems such as NV-centres and atoms in a cavity, and (4) fermionic systems with different symmetry constraints.

All these examples are presented within a common geometric framework.

Q 43.2 Thu 14:30 Kinosaal
Optimal coherent control to counteract dissipation — •Clemens Gneiting, Simeon Sauer, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Genuine quantum features such as entanglement or coherence are resources as precious as fragile, and their uncovering usually requires strong efforts in isolating and controlling quantum systems. While there has been unprecedented progress in the quantum control of various model systems, e.g. trapped ions, quantum dots, or cold atoms, it is impossible to fully suppress the detrimental effect of decoherence. Standard optimal control techniques therefore focus on accessing quantum features in a finite, generically short time window. We investigate to what extent coherent Hamiltonian control can enduringly counteract the detrimental effect of decoherence. Explicitly, we determine Hamiltonians that optimally stabilize given control objectives in the presence of dissipation. Our method is applicable to both static and periodically time-dependent Hamiltonians. To demonstrate this, we discuss the maximum asymptotic two-qubit entanglement that can be preserved by static and periodic coherent control in the presence of a dissipation-inducing environment.

[1] Simeon Sauer, Clemens Gneiting, and Andreas Buchleitner, Phys. Rev. Lett. **111**, 030405 (2013)

Q 43.3 Thu 14:45 Kinosaal
Coherence as a Resource — •Tillmann Baumgratz, Marcus Cramer, and Martin B. Plenio — Institut für Theoretische Physik, Albert-Einstein-Allee 11, Universität Ulm, 89069 Ulm, Germany

We adopt the viewpoint of coherence as a physical resource to discuss the value of coherent states with respect to incoherent states [1]. We determine defining conditions for measures of coherence and identify classes of functionals that satisfy these conditions and other, at first glance natural quantities, that do not qualify as coherence measure. We identify a maximally coherent state and discuss its value for implementing general quantum operations when having only access to incoherent operations.
[1] T. Baumgratz, M. Cramer, and M.B. Plenio, arXiv:1311.0275.

Q 43.4 Thu 15:00 Kinosaal
Efficient Optimal Control for a Unitary Operation under Dissipative Evolution — •Michael H. Goerz, Daniel M. Reich, and Christiane P. Koch — Universität Kassel, Institut für Theoretische Physik

We show that optimizing a quantum gate for an open quantum system requires propagation of only three states irrespective of the dimension of Hilbert space. This represents a significant reduction in computational resources compared to the complete basis of Liouville space that is commonly believed necessary for this task. The reduction is based on two observations: The target is not a general dynamical map but a unitary operation; and the gate fidelity of a unitary operation can be estimated from a reduced set of properly chosen states. We illustrate our claim by optimization of two-qubit gates for trapped atoms and for superconducting qubits. The choice of states and their relative weight can be guided by physical understanding; for example, in the case of the Rydberg gate, the Hamiltonian only allows for diagonal gates, allowing to further reduce the number of required states to two. For both examples, we find that the optimization with a reduced set of states reaches gate fidelities that are only limited by the decoherence.

Q 43.5 Thu 15:15 Kinosaal
Manipulating a qubit through the backaction of sequential partial measurements and real-time feedback — •Cristian Bonato[1], Machiel Blok[1], Matthew Markham[2], Daniel Twitchen[2], Viatcheslav Dobrovitski[3], and Ronald Hanson[1] — [1]Kavli Institute of Nanoscience Delft, Delft University of Technology, PO Box 5046, 2600 GA Delft, The Netherlands — [2]Element Six Ltd., Kings Ride Park, Ascot, Berkshire SL5 8BP, UK — [3]Ames Laboratory and Iowa State University, Ames, Iowa 50011, USA

Quantum measurements not only extract information from a system but also alter its state. Although the outcome of the measurement is probabilistic, the backaction imparted on the measured system is accurately described by quantum theory. Therefore, quantum measurements can be exploited for manipulating quantum systems without the need for control fields. We demonstrate measurement-only state manipulation on a nuclear spin qubit in diamond by adaptive partial measurements. We implement the partial measurement via tunable correlation with an electron ancilla qubit and subsequent ancilla readout. We vary the measurement strength to observe controlled wavefunction collapse and find post-selected quantum weak values. By combining a novel quantum non-demolition readout on the ancilla with real-time adaption of the measurement strength we realize steering of the nuclear spin to a target state by measurements alone. Besides being of fundamental interest, adaptive measurements can improve metrology applications and are key to measurement-based quantum computing.

Q 43.6 Thu 15:30 Kinosaal
Time-Continuous Bell Measurements — •Denis Vasilyev[1], Sebastian Hofer[2], Markus Aspelmeyer[2], and Klemens Hammerer[1] — [1]ITP, Leibniz University Hannover, Germany — [2]VCQ, University of Vienna, Austria

We combine the concept of Bell measurements, in which two systems are projected into a maximally entangled state, with the concept of continuous measurements, which concerns the evolution of a continuously monitored quantum system. For such time-continuous Bell measurements we derive the corresponding stochastic Schrödinger equations, as well as the unconditional feedback master equations [1].

Our results apply to a wide range of physical systems, and are easily adapted to describe an arbitrary number of systems and measurements. Time-continuous Bell measurements therefore provide a versatile tool for the control of complex quantum systems and networks. As examples we show that (i) two two-level systems can be deterministically entangled via homodyne detection, tolerating photon loss up to 50%, and (ii) a quantum state of light can be continuously teleported to a mechanical oscillator, which works under the same conditions as are required for optomechanical ground-state cooling.

[1] PRL 111, 170404 (2013)

Q 43.7 Thu 15:45 Kinosaal
Quantum Subdivision Capacities and Continuous-Time Quantum Coding — Alexander Müller-Hermes, •David Reeb, and Michael Marc Wolf — Department of Mathematics, Technische Universität München, 85748 Garching, Germany

Quantum memories can be regarded as quantum channels that transmit information through time without moving it through space. Aiming at a reliable storage of information we may thus not only encode at the beginning and decode at the end, but also intervene during the transmission - a possibility not captured by the ordinary capacities in Quantum Shannon Theory. In this work we introduce capacities that take this possibility into account and study them in particular for the transmission of quantum information via dynamical semigroups of Lindblad form. When the evolution is subdivided and supplemented by additional continuous semigroups acting on arbitrary block sizes, we show that the capacity of the ideal channel can be obtained in all cases. If the supplementary evolution is reversible, however, this is no longer the case. Upper and lower bounds for this scenario are proven. Finally, we provide a continuous coding scheme and simple examples showing that adding a purely dissipative term to a Liouvillian can sometimes increase the quantum capacity.