Q 70: Quanteninformation: Konzepte und Methoden 6

Time: Friday 14:00–15:45 Location: V7.03

Q 70.1 Fri 14:00 V7.03

Quantum Optimal Control in Action. I: Overview — •Thomas Schulte-Herbrüggen[1], Shai Machnes[2], and Ville Bergholm[1] — [1]TU-Munich, Dept. Chem. — [2]University of Ulm, Inst. Theor. Phys.

For implementing high-precision quantum simulation and quantum computation in given experimental set-ups, optimal control tools are establishing themselves as indispensable.

Starting from practical examples of control problems (as in superconducting solid-state devices, cavity qed), we elucidate the unified framework of *bilinear control systems* underlying the matlab-based quantum optimal-control platform dynamo [1]. It provides optimised steerings to all the typical control problems such as state transfer and synthesis of unitary gates or of quantum maps [2] in closed and open Markovian or non-Markovian systems.

We sketch a plethora of applications reaching from Josephson elements, spins in quantum dots to ion traps etc. Finally, we point out features of state-of-the-art algorithms implemented [1].

References:

[1] S. Machnes et al., Phys. Rev. A 84 (2011) 022305 [doi:10.1103/PhysRevA.84.022305]

[2] T. Schulte-Herbrüggen et al., J. Phys. B 44 (2011) 154013 [doi:10.1088/0953-4075/44/15/154013]

Q 70.2 Fri 14:15 V7.03

Quantum Optimal Control in Action. II: Demonstration — •Ville Bergholm[1], Shai Machnes[2], and Thomas Schulte-Herbrüggen[1] — [1]TU-Munich, Dept. Chem. — [2]University of Ulm, Inst. Theor. Phys.

We demonstrate the unified quantum optimal control package dynamo in a number of hands-on control problems on the computer. Examples reach from time-optimal quantum gate synthesis in closed systems to relaxation-optimised quantum map synthesis in open systems, as well as spectroscopic state transfer. These pulse-engineering problems occur in a wide range of applications including Josephson circuits, cavity grids, spins in quantum dots, ion traps etc.

The trade-offs associated with different experimental constraints will be elucidated. Special emphasis will be put on controlling a wide range of parameters in open dissipative systems.

References:

[1] S. Machnes et al., Phys. Rev. A 84 (2011) 022305 [doi:10.1103/PhysRevA.84.022305]

[2] dynamo is available under: http://qlib.info/

Q 70.3 Fri 14:30 V7.03

Fermionic quantum systems: controllability and the parity superselection rule — •Robert Zeier[1], Zoltán Zimborás[2], Michael Keyl[2], and Thomas Schulte-Herbrüggen[1] — [1]Department Chemie, Technische Universität München, Lichtenbergstrasse 4, 85747 Garching, Germany — [2]Institute for Scientific Interchange Foundation, Villa Gualino, Viale Settimio Severo 75, 10131 Torino, Italy

We study controllability and simulability of fermionic quantum systems which observe the parity superselection rule. Superselection rules describe the existence of non-trivial symmetries (e.g., the parity operator) that commute with all physical observables. We present examples of fermionic sytems such as quasifree and translation-invariant ones and develop readily applicable conditions for the controllability of fermionic systems by studying their symmetries and generalizing the work of [1]. As an application, we discuss under which conditions fermionic and spin systems can simulate each other.

[1] R. Zeier and T. Schulte-Herbrüggen, J. Math. Phys. 52, 113510 (2011)

Q 70.4 Fri 14:45 V7.03

Control of correlated quantum dynamics — •Simone Montangero — Ulm University, Germany

We present different applications of optimal control to correlated quantum systems as the optimization of production of stable, robust, entangled states. We present experimental proposal of control of many body quantum systems and we introduce the concept of complexity of the optimization task.

Q 70.5 Fri 15:00 V7.03

Towards quantum computation with multi-particle interference — •Vincenzo Tamma[1], Yanhua Shih[2], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik, Universität Ulm — [2]Physics Department, Univ. of Maryland, Baltimore County

One of the main challenges in quantum computation is the realization of entangled states with a large number of particles.

We have experimentally demonstrated a novel factoring algorithm which relies only on optical multi-path interference and on the periodicity properties of Gauss sums with continuous arguments [1,2,3]. An interesting implementation of such a method can, in principle, take advantage of matter-wave interferometers characterized by long-time evolution of a BEC in microgravity [4].

A more recent approach to factorization aims to achieve an exponential speed-up without entanglement by exploiting multi-particle m-order interference. In this case, the basic requirement for quantum computation is interference of an exponentially large number of multi-particle amplitudes.

[1] V. Tamma, H. Zhang, X. He, A. Garuccio, W.P. Schleich, and Y. Shih, Phys. Rev. A Rap. Com. 83, 020304 (2011). [2] V. Tamma, H. Zhang, X. He, A. Garuccio, W.P. Schleich, and Y. Shih, Found. of Phys., 1-11 (2010). [3] V. Tamma, H. Zhang, X. He, A. Garuccio and Y. Shih, J. Mod. Opt. 56, 2125-2132 (2009). [4] T. van Zoest et al., Science 328, 1540 (2010).

Q 70.6 Fri 15:15 V7.03

Breaking of momentum-space reflection invariance in fermionic models — •Zoltan Zimboras and Zoltan Kadar — Quantum Information Theory Group, ISI, Torino.

We prove that the ground state of a (translation-invariant) quadratic fermionic Hamiltonian can only break momentum-space reflection invariance, if the Hamiltonian is gapless and the ground state itself has algebraic decaying correlations. We discuss the relevance of this theorem in Hartree-Fock approxiamtions, in quantum control, and in entanglement theory [1].

[1] Zoltan Kadar and Zoltan Zimboras, Phys. Rev. A 82, 032334 (2010).

Q 70.7 Fri 15:30 V7.03

Optimizing the presence of states in phase space regions — •Christoph Tempel, Lev Plimak, Karl Vogel, and Wolfgang P. Schleich — Institute of Quantum Physics, Ulm University

The problem of maximizing the integral of the Wigner function of a quantum state over a region in phase space emerges in the context of quantum tomography [1]. For an elliptical region the optimal state is squeezed vacuum [2]. Furthermore, such an optimal state may be characterized [3] as an eigenstate of the so-called region operator in the conventional Hilbert space. We combine the results of [2] and [3], using the fact that the region operator of a disconnected region is a sum of region operators of the components, giving rise to an efficient numerical approach to the optimization problem. For regions consisting of two non-overlapping disks, we find the said integral to be larger than one, which is a purely quantum effect. We also demonstrate that in the limit of well separated disks one encounteres a coherent superposition of coherent states centered at the disks (the so-called "cat state").

[1] U. Leonhardt, *Measuring the Quantum State of Light*, Cambrigde Univ. Press, 1997.

[2] P. Flandrin, *ICASSP-88* **4** 2176, 1988.

[3] A. J. Bracken et. al., *Acta Physica Hung. B* **20** 121, 2004.