MP 3: Quanten-Information III

Time: Tuesday 10:30–12:30 Location: SPA SR125

MP 3.1 Tue 10:30 SPA SR125

Operationally-Motivated Uncertainty Relations for Joint Measurability and the Error-Disturbance Tradeoff — Joseph M. Renes and •Volkher B. Scholz — Institute for Theoretical Physics, ETH Zurich, Wolfgang-Pauli-Str. 27, 8093 Zurich, Switzerland

We derive uncertainty relations for both joint measurability and the error-disturbance tradeoff in terms of the probability of distinguishing the actual operation of a device from its hypothetical ideal. Our relations provide a clear operational interpretation of two main aspects of the uncertainty principle, as originally formulated by Heisenberg. The first restricts the joint measurability of observables, stating that noncommuting observables can only be simultaneously determined with a characteristic amount of indeterminacy. The second describes an error-disturbance tradeoff, noting that the more precise a measurement of one observable is made, the greater the disturbance to noncommuting observables.

Our relations are explicitly state-independent and valid for arbitrary observables of discrete quantum systems, and are also applicable to the case of position and momentum observables. They may be directly applied in information processing settings, for example to infer that devices which can faithfully transmit information regarding one observable do not leak information about conjugate observables to the environment. Though intuitively apparent from Heisenberg's original arguments, only limited versions of this statement have previously been formalized.

MP 3.2 Tue 10:50 SPA SR125

Controlling atoms in a cavity - applications of infinite dimensional Lie-algebras — •Michael Keyl[1], Robert Zeier[2], and Thomas Schulte-Herbrüggen[2] — [1]Zentrum Mathematik, M5, Technische Universität München, Boltzmannstrasse 3, 85748 Garching, Germany — [2]Department Chemie, Technische Universität München, Lichtenbergstrasse 4, 85747 Garching, Germany

We consider control theory for a number of two-level atoms interacting with one mode of the electromagnetic field in a cavity. In the rotating wave approximation this provides a very useful toy-model to study several aspects of quantum control theory in infinite dimensions, in particular the emergence of infinite dimensional system algebras. In this context we provide a short discussion of problems arising with infinite dimensional Lie-algebras and Lie-algebras consisting of unbounded operators. For the models under consideration these problems can be solved by splitting the set of control Hamiltonians up into two groups: The first obeys an Abelian symmetry and can be treated in terms of infinite dimensional Lie-algebras and strongly closed subgroups of the unitary group of the system Hilbert space. The second breaks this symmetry and their discussion needs new arguments. At the end full controlability can be achieved in a certain strong sense. As an example we study a time dependent version of the Jaynes Cummings model and show that with an appropriate tuning of the coupling constants every unitary of the coupled system (atom and cavity) can be approximated with arbitrary small error.

MP 3.3 Tue 11:10 SPA SR125

Unifying Fixed-Point Engineering with the Stabiliser Formalism of Graph States and Topological States — •Thomas Schulte-Herbrüggen[1], Corey O'Meara[1], and Gunther Dirr[2] — [1]Dept. Chem., TU-München (TUM) — [2]Math. Inst., University of Würzburg

We present a unified practical Lie-framework for fixed-point engineering which includes as special cases the stabiliser formalisms for graph states and topological states.

Quantum evolution in open Markovian systems takes the form of an affine map with an illustrative geometry. It consists of a unital part ('rotation and compression') and a translational part, the latter representing the shift (if any) from the chaotic state (identity) towards fixed points of different type.

For a plethora of examples, we demonstrate how to exploit the geometry of such translations for systematic fixed-point engineering. In the framework of Lie-semigroups a unified practical view emerges: (1) It shows how to relate a desired target state via its centraliser (or commutant) to translations and, in turn, to the corresponding Lindblad noise generators driving the system into the desired targets. (2) Analogously, *graph states* can be obtained from their stabilisers (seen as elements of the maximally abelian subalgebra of the centraliser) cast into translations and the corresponding Lindblad generators. (3) *Topological states*, as for the toric code, are engineered likewise by turning the star and plaquette operators (seen as abelian centraliser elements) into translations and Lindblad generators.

MP 3.4 Tue 11:30 SPA SR125

Efficient achievability for quantum information theoretic protocols using decoupling theorems — •Christoph Hirche and Ciara Morgan — Leibniz Universität, Hannover, Germany

Proving achievability of protocols in quantum Shannon theory usually does not consider the efficiency at which the goal of the protocol can be achieved. Nevertheless it is known that protocols such as coherent state merging are efficiently achievable at optimal rate. We aim to investigate this fact further in a general one-shot setting, by considering certain classes of decoupling theorems and give exact rates for these classes. Moreover we compare results of general decoupling theorems using Haar distributed unitaries with those using smaller sets of operators, in particular ϵ-approximate 2-designs. We also observe the behavior of our rates in special cases such as ϵ approaching zero and the asymptotic limit.

MP 3.5 Tue 11:50 SPA SR125

Thermalization, quantum correlation and entanglement in exactly solvable models. — •Ming-Chiang Chung — National Chung-Hsing University, Taichung, Taiwan

The generalized Gibbs ensemble introduced for describing few body correlations in exactly solvable systems following a quantum quench is related to the way in which operators sample, in the limit of infite time after the quench, the quantum correlations present in the initial state. The emergence of the generalized Gibbs ensemble is thus analytically established for the quantum Ising and XX chains in the thermodynamic limit. For these models and for a broad class of initial states, which includes both translationally and non-translationally invariant states, the validity of the generalized Gibbs ensemble for simple correlation functions of both local and non-local operators is demonstrated provided certain conditions are met. The relation between quench dynamics and entanglement will be discussed. And a measurement of quantum entanglement through the quench dynamics will be proposed.

MP 3.6 Tue 12:10 SPA SR125

Haag Duality in Kitaev's Quantum Double Model for Finite Groups — •Leander Fiedler and Pieter Naaijkens — Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

Kitaev's quantum double model for finite groups is a spin model on a 2D lattice that exhibits anyonic excitations. It is designed to perform quantum computations and in fact for certain groups it allows even for universal quantum computation. The latter is made possible by braid statistics of the anyons which are encoded in the superselection structure of the model.

We show that algebras of observables localized in cone-like regions fulfill Haag duality in the vacuum representation. This means that in the vacuum representation observables which commute with all observables outside the cone are exactly those localized inside the cone.

As an application we consider an analysis of the superselection structure of the model for finite abelian groups. We show that in this case the superselection structure is given by conelike localized endomorphisms describing single excitations of the model. The latter can be described by representations of Drinfeld's quantum double of the underlying group. This resembles analogue results for Kitaev's toric code model.