QI 17: Quantum Information: Concept and Methods I

Time: Wednesday 9:30–11:15 Location: HFT-TA 441

QI 17.1 Wed 9:30 HFT-TA 441

Noisy Stabilizer Formalism — •Maria Flors Mor Ruiz and Wolfgang Dür — Universität Innsbruck, Institut für Theoretische Physik, Technikerstraße 21a, 6020 Innsbruck, Austria

Despite the exponential overhead to describe general multi-qubit quantum states and processes, efficient methods for certain state families and operations have been developed and utilized. The stabilizer formalism and the Gottesman-Knill theorem, where pure stabilizer or graph states are manipulated by Clifford operations and Pauli measurements, are prominent examples, and these states play a major role in many applications in quantum technologies. This talk presents the developed noisy stabilizer formalism, i.e., a method that allows one to efficiently describe and follow not only pure states under Clifford operations and Pauli measurements but also Pauli noise processes acting on such stabilizer states, including uncorrelated and correlated dephasing and single- or multiple-qubit depolarizing noise. The method scales linearly in the number of qubits of the initial state, but exponentially in the size of the target state. Thus, whenever a noisy stabilizer state is manipulated by means of local Pauli measurements such that a multipartite entangled state of a few qubits is generated, one can efficiently describe the resulting state.

QI 17.2 Wed 9:45 HFT-TA 441

Wilsonian Renormalization as a Quantum Channel — •Matheus Henrique Martins Costa[1], Jeroen van den Brink[1,2], Flávio de Souza Nogueira[1], and Gastao Inácio Krein[3] — [1]IFW Dresden, Dresden, Germany — [2]Würzburg-Dresden Cluster of Excellence, Dresden, Germany — [3]Instituto de Física Teórica - UNESP, Sao Paulo, Brazil

We show that the Wilsonian formulation of the renormalization group (RG) defines a quantum channel acting on the momentum-space density matrices of a quantum field theory. This information-theoretical property of the RG allows us to derive a remarkable consequence for the vacuum of theories at a fixed point: they have no entanglement between momentum scales.

With this result we also begin an investigation of behavior of momentum-space entanglement across the phase transition in the Sine-Gordon model and, more generally, we derive constraints on the form of the ground state of fixed-point theories, possibly being useful for the development of numerical techniques.

QI 17.3 Wed 10:00 HFT-TA 441

Achievable state transformations under rotational invariance — •Fynn Otto and Konrad Szymański — Universität Siegen, Germany

Rotational invariance is a fundamental characteristic of physical interactions, naturally leading to rotationally covariant dynamics. In communication between distant parties, the lack of a common reference frame imposes similar constraints on the effective transformations: they must be independent of the unknown reference, and thus are rotationally covariant as well. This feature is captured by the formalism of $SU(2)$-covariant operations: those that commute with the actions of all group elements. We present an analytical characterization of covariant transformations and introduce semidefinite programs to examine which states are reachable from a given input using $SU(2)$-covariant channels. Our results improve our understanding of the transformations of directional information carriers and showcase the mechanisms of quantum operations lacking a reference frame.

QI 17.4 Wed 10:15 HFT-TA 441

Cost-efficient readout error mitigation — •Ákos Budai[1,2], Zoltán Zimborás[2], and András Pályi[1] — [1]Budapest University of Technology and Economics — [2]Wigner RCP, Hungarian Academy of Sciences

Readout error mitigation (REM) is an efficient tool to improve the functionality of Noisy Intermediate-Scale Quantum (NISQ) devices. In most superconducting prototype quantum computers, the readout error dominates the errors of individual gates. The level of improvement gained by REM depends on the error probabilities and number of shots available. In this work, we quantify the efficiency of REM in quantum state tomography. We derive approximate analytical results for the mean squared error of the estimation. We start by introducing the measurement protocol for the case of single-qubit tomography, then we generalize to the N-qubit case and derive the scaling properties of the calculation with the number of qubits and the order of the Taylor expansion.

QI 17.5 Wed 10:30 HFT-TA 441

Imaginary Time Evolution: A Lie-theoretic study with applications to Quantum Algorithms and Statistical Physics — •Roberto Gargiulo[1], Matteo Rizzi[1,2], and Robert Zeier[1] — [1]Forschungszentrum Jülich GmbH, Peter Grünberg Institute, Quantum Control (PGI-8), Jülich 52425, Germany — [2]University of Cologne, Institute for theoretical physics (THP), 50937 Cologne, Germany

The imaginary time evolution has long been used in physics to relate dynamical and equilibrium properties. We discuss this duality in the case of variational quantum algorithms, where a systematic study of symmetries via Lie theory can be used to relate compact real Lie algebras (such as $\mathfrak{su}(n), \mathfrak{so}(n), \mathfrak{sp}(n)$) to the their noncompact "imaginary-time" counterparts.

This connection is exemplified for the transfer-matrix method in classical spin systems, especially for the two-dimensional Ising model. This is also related to the standard ansatz for the quantum approximate optimization algorithm aimed at solving the maximum-cut graph problem. By leveraging this Lie-theoretic approach, we study similarities and differences between the two counterparts and explore potential applications.

QI 17.6 Wed 10:45 HFT-TA 441

Graphical Calculus for Non-Gaussian Quantum States — •Lina Vandré[1,2], Boxuan Jing[2], Yu Xiang[2], Otfried Gühne[1], and Qiongyi He[2] — [1]University of Siegen — [2]School of Physics, Peking Universit

Multipartite entangled states are an important resource for quantum computing, quantum communications, and quantum metrology. The multi-mode complex entangled quantum states prepared in experiments are classified into continuous variable (CV) and discrete variable (DV) systems according to the type of variables.

When analysing multiparticle entanglement, the exponentially increasing dimension of the Hilbert space is a challenging factor. It is a natural approach to consider specific families of states that enable a simple description and useful properties. Graph and hypergraph states form such families of multi-qubit quantum states, as they can be described by a graphical formalism. They have applications in various contexts, for example, measurement-based quantum computation or self-testing. The graphical formalism of graph and hypergraph states can be generalised to CV systems. While CV graph states are Gaussian, general hypergraph states are non-Gaussian. There are already several works about CV graph states, but there is very little exploration of CV hypergraph states.

In this talk, I introduce graphical rules for Gaussian operations applied to non-Gaussian hypergraph states. I show how these rules help to prepare complex non-Gaussian states as well as how the formalism can be used for characterizing non-Gaussian states.

QI 17.7 Wed 11:00 HFT-TA 441

What connects entangled photons? — •Eugen Muchowski — Primelstrasse 10, 85591 Vaterstetten

A local realistic model is presented which reproduces the quantum mechanical predictions for expectation values with polarization measurements, but is not based on shared statistical parameters. Instead, the coupling of the entangled particles is based on initial conditions and conservation of spin angular momentum. The model refutes Bell's theorem and also explains teleportation and entanglement swapping in a local way. It is also shown which error in Bell's derivation leads to Bell's inequality failing to correctly describe the relationships between expectation values from quantum mechanics. The consequences for quantum computing are discussed.