QI 5: Quantum Entanglement I

Time: Monday 17:00–18:30 Location: HS IX

Invited Talk QI 5.1 Mon 17:00 HS IX
Representation Theory for Quantum Algorithms and Protocols — Dmitry Grinko, •Adam Burchardt, and Maris Ozols — QuSoft, University of Amsterdam, Centrum Wiskunde & Informatica, Amsterdam, The Netherlands

In this talk, we highlight the relevance of representation theory in various quantum information tasks. Our focus is on the (mixed) Schur transform and its applications. In particular, we present an efficient quantum circuit for implementing the mixed Schur transform. We then demonstrate how this transform can be applied to Port-Based Teleportation (PBT). Specifically, we provide efficient quantum circuits for optimal measurements in various PBT schemes, which use the mixed Schur transform as a subroutine. This presentation is based on two recent papers: arXiv:2310.02252 and arXiv:2312.03188.

QI 5.2 Mon 17:30 HS IX
Ket.jl: Toolbox for quantum information, nonlocality, and entanglement — Mateus Araújo[1], Peter Brown[2], Sébastien Designolle[3], •Carlos de Gois[4], and Lucas Porto[5] — [1]Universidad de Valladolid — [2]Télécom Paris — [3]Zuse-Institut Berlin — [4]Universität Siegen — [5]Universidade Estadual de Campinas

Ket.jl is a versatile toolbox for doing quantum information in the Julia programming language. This contribution will offer a brief, hands-on introduction to its capabilities. Key features to be discussed include parallelized algorithms for computing local bounds of Bell inequalities, a generic see-saw method for maximizing the quantum value of any Bell functional, and tools for computing the incompatibility robustness of quantum measurements. For entanglement theory, the library offers, among others, methods for computing the entanglement entropy and the Schmidt number of quantum states, and to construct witnesses for genuine multipartite entanglement – all of which leverage an implementation of the symmetric extensions hierarchy.

Notably, Ket.jl provides flexible implementations for subsystem permutation, partial trace and partial transpose, designed to work with abstract data types. This flexibility enables integration with JuMP for formulating optimization programs. Additional features include utilities for generating random operators, computing norms and entropies, and constructing mutually unbiased bases and symmetric informationally complete POVMs with arbitrary precision.

QI 5.3 Mon 17:45 HS IX
Metrological entanglement criteria — •Szilárd Szalay[1] and Géza Tóth[1,2] — [1]Wigner Research Centre for Physics, Budapest, Hungary — [2]University of the Basque Country UPV/EHU, Bilbao, Spain

We show that the Quantum Fischer Information in quantum metrology puts a lower bound on the Average Size of Entangled Subsystems. This is a particular case of a new kind of multipartite entanglement criteria, restricting the relative weights of the pure states of different average size of entangled subsystems in the mixture. We illustrate the strength of this convex criterion and compare it to the original metrological entanglement criterion in terms of the usual entanglement depth.

QI 5.4 Mon 18:00 HS IX
New methods for high dimensional entanglement in PPT states — •Robin Krebs and Mariami Gachechiladze — Technische Universität Darmstadt, Darmstadt, Hesse, Germany

Creation and manipulation of high dimensional entanglement is fundamental for quantum information protocols. To understand the structure of high-dimensional entanglement and attain the optimal witnesses to certify the entanglement dimension, analyzing the Schmidt Number (SN) of PPT states is necessary, which is notoriously hard to do. In this work, we take a step forward in developing novel methods for finding high SN PPT states. To do this, we work with the so-called projection property of high-dimensional entangled states: Any bound entangled state with SN k can be obtained via local projections on a higher dimensional PPT state with SN $(k+1)$. This larger state can be viewed as an extended state. More generally, this defines a convex cone of PPT extensions of a fixed initial state. Then, the (extremal) intersection geometry of the extension cone and PPT set in the corresponding dimension is investigated. This way, it is possible to obtain new candidates of high SN states. For such extreme points of the PPT set, we derive a necessary and sufficient SN criterion applicable to the extended states. On various examples, we observe that extensions of low degrees do not increase the SN, which constrains the search process. Instead, here, we discover patterns for the original fixed state that lead to high SN extensions. This way, we find the smallest known instance of three-dimensional PPT entanglement in 4×5-dimensional Hilbert spaces, improving our results for 5×5-dimensional states.

QI 5.5 Mon 18:15 HS IX
Chiral Symmetries of Multiparticle Entanglement — •Sophia Denker[1], Satoya Imai[2], and Otfried Gühne[1] — [1]Naturwissenschaftlich-Technische Fakultät, Universität Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany — [2]QSTAR, INO-CNR, and LENS, Largo Enrico Fermi 2, 50125 Firenze, Italy

Symmetries play a central role in physics. Particularly in entanglement theory many works investigate the separability of states with certain symmetries. However, while in bipartite systems quantum states can show symmetric or antisymmetric behavior, when exploring multipartite systems also quantum states with chiral symmetries can appear.

In this work we investigate chiral subspaces with respect to their entanglement properties. Starting with the case of three qubits we show that theses subspaces are highly entangled with respect to their geometric measure of entanglement and are further related to measurements that are useful to estimate entanglement. We then consider these spaces in higher dimensions and define operators related to the structure constants of Lie algebras whose eigenspace coincides with the sum of those chiral subspaces. While we find that these operators are sums of permutations and therefore invariant under unitary transformations, we further translate those operators to sums of permutations and their partial transposed leading to subspaces invariant under orthogonal transformations, which are even more entangled.