QuILT Day
Thursday, November 14, 2019

MEETING ROOM

All lectures from 9:30am–3pm will be held in room 300 (Diboll Gallery) of the new Commons building at Tulane University. A projector is available for presentations during these lectures.

All lectures from 3:30pm–5pm will be held in room 122 of Lindy Boggs Hall at Tulane University. A projector and a whiteboard are available for presentations during these lectures.

PROGRAM

9:30–10:00	Vishal Katariya — Google quantum supremacy overview
10:00–10:30	Sanjaya Lohani — Machine learning assised quantum state estimation
10:30–11:00	Coffee Break — PJ's coffee
11:00–11:30	Andre Kornell — Analogs of functions in quantum information theory
11:30–12:00	Soorya Rethinasamy — Relative entropy and catalytic relative majorization
12:00–14:00	Lunch Break — Tulane Student Union
14:00–14:30	Fatemeh Mostafavi — A dynamical approach to low-cost shortcut to adiabaticity
14:30–15:00	Kevin Valson Jacob — Characterizing quantum detectors by Wigner functions
15:00–15:30	Coffee Break — PJ's coffee
15:30–16:00	Chenglong You — Identification of light sources using machine learning
16:00–16:30	Kunal Sharma — Noise resilience of variational quantum compiling
16:30–17:00	Denys Bondar — Classical–quantum correlation dynamics: The approach of Koopman wavefunctions

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ABSTRACTS
(in alphabetical order by speaker surname)

Speaker: **Denys Bondar** (Tulane University)
Title: *Classical–quantum correlation dynamics: The approach of Koopman wavefunctions*
Abstract: We address the long-standing problem of formulating a dynamical theory of classical–quantum coupling. The proposed model not only describes the influence of a classical system onto a quantum one, but also the reverse effect—the quantum backreaction. These interactions are described by a new Hamiltonian wave equation overcoming shortcomings of currently employed models. For example, the density matrix of the quantum subsystem is always positive definite. While the Liouville density of the classical subsystem is generally allowed to be unsigned, its sign is shown to be preserved in time for a specific infinite family of hybrid classical–quantum systems. The proposed description is illustrated and compared with previous theories using the exactly solvable model of a degenerate two-level quantum system coupled to a classical harmonic oscillator.

Speaker: **Kevin Valson Jacob** (Louisiana State University)
Title: *Characterizing quantum detectors by Wigner functions*
Abstract: Photodetection has been making consistent progress with rapidly developing optical quantum technology. In this work, we propose a method for characterizing a photodetector by reconstructing the Wigner functions of the detector's Positive-Operator-Value-Measure (POVM) elements. This method exploits weak-field homodyning which exploits the wave-like and particle-like properties of light. The method uses displaced thermal mixtures as probes to the detector and reconstructs the Wigner function of the photodetector POVM elements from its outcome statistics. In order to make the reconstruction robust to the experimental noise, we use techniques from quadratic convex optimization.

Speaker: **Vishal Katariya** (Louisiana State University)
Title: *Google's demonstration of quantum supremacy: the details*
Abstract: "Quantum supremacy" has been a landmark in the field of quantum computing that a number of groups around the world have been working towards. The Google AI Quantum team was the first to show it, using a computational task that involved sampling the outputs from a distribution of random quantum circuits. This task was engineered to be hard for classical computers; estimates show that this particular task takes about 200 seconds on Google's Sycamore 53-qubit chip, but could take anywhere between 2.5 days and 10,000 years on the best supercomputers that currently exist. By testing and verifying their method on smaller circuits, the Google AI Quantum team concluded that their quantum computer's successful sampling of 53-qubit random circuits constituted an experimental realization of quantum supremacy. This talk will cover some of the technical details of their effort, including the sampling task involved, the benchmarking tests used, and how the estimate of running time on a classical computer was computed.

Speaker: **Andre Kornell** (Tulane University)
Title: *Analogs of functions in quantum information theory*
Abstract: Quantum physics is notoriously unlike classical physics, but our formal descriptions of quantum systems echo those of classical systems to a remarkable degree. The heuristic quantization methods of theoretical physics are a widely encountered expression of this analogy. Noncommutative mathematics offers another expression of it. For example, both the Hermitian and the unitary matrices of quantum physics are analogs of ordinary functions in classical physics, but in somewhat different ways. Both act as operators on the same Hilbert space, but unitary operators correspond classically to functions on the

phase space, whereas Hermitian matrices correspond classically to functions from the phase space to the real line. It is well known that these apparently different analogies can be treated simultaneously within noncommutative mathematics. Specifically, both Hermitian matrices and unitary matrices correspond to function-like morphisms in an appropriate category. This talk will flesh out these analogies to a coherent "noncommutative dictionary for discrete structures", beginning with a description of the objects that we call quantum sets, and of the binary relations between them, essentially the quantum relations of Nik Weaver.

Speaker: **Sanjaya Lohani** (Tulane University)
Title: *Machine learning assised quantum state estimation*
Abstract: We demonstrate a machine learning technique to efficiently reconstruct quantum states directly from a set of measurement results. Our method reduces the computational cost required to have full quantum state tomography. For a wide range of noisy measurement scenarios, we show a significant enhancement in the average fidelity when compared to the conventional non-machine learning approach. In addition, we find a consistent enhancement in average fidelity even when the tomographic measurement data is incomplete.

Speaker: **Fatemeh Mostafavi** (Louisiana State University)
Title: *A dynamical approach to low-cost shortcut to adiabaticity*
Abstract: By introducing a class of non-Hermitian Hamiltonians, we propose an approach to low-cost shortcut to adiabaticity. Our approach focuses on dynamical properties of the system. In particular, in our proposed 2×2 Hamiltonians, one eigenvalue is absolutely real and the other one is complex. This specific form of eigenvalues helps us to exponentially decay the population in an undesired eigenfunction or amplify the population in the desired state while keeping the probability amplitude in the other eigenfunction conserved. This provides us with a powerful method to have a diabatic process with the same outcome as its corresponding adiabatic process. In contrast to standard shortcuts to adiabaticity, our Hamiltonians have a much simpler form with a lower thermodynamic cost. Furthermore, we show that our approach can be extended to higher dimensions using the parameters associated with our 2×2 Hamiltonians. Our proposed Hamiltonians can be used for tunable mode selection and filtering in acoustics, electronics, and optics.

Speaker: **Soorya Rethinasamy** (Louisiana State University and Birla Institute of Technology and Science, Pilani)
Title: *Relative entropy and catalytic relative majorization*
Abstract: Given two pairs of quantum states, a fundamental question in the resource theory of asymmetric distinguishability is to determine whether there exists a quantum channel converting one pair to the other. In this work, we reframe this question in such a way that a catalyst can be used to help perform the transformation, with the only constraint on the catalyst being that its reduced state is returned unchanged, so that it can be used again to assist a future transformation. What we find here, for the special case in which the states in a given pair are commuting, and thus quasi-classical, is that this catalytic transformation can be performed if and only if the relative entropy of one pair of states is strictly larger than that of the other pair. This result endows the relative entropy with a fundamental operational meaning that goes beyond its traditional interpretation in the setting of independent and identical resources. Our finding thus has an immediate application and interpretation in the resource theory of asymmetric distinguishability, and we expect it to find application in other domains.

Speaker: **Kunal Sharma** (Louisiana State University)
Title: *Noise resilience of variational quantum compiling*
Abstract: Variational hybrid quantum-classical algorithms (VHQCAs) are near-term algorithms that leverage classical optimization to minimize a cost function, which is efficiently evaluated on a quantum computer. Recently, VHQCAs have been proposed for a quantum compiling, where a target unitary U is compiled

into a short-depth gate sequence V. In this talk, I will present a surprising form of noise resilience for these algorithms. Namely, one often learns the correct gate sequence V (i.e., the correct variational parameters) despite various sources of incoherent noise acting during the cost-evaluation circuit. Our main results are rigorous theorems stating that the optimal variational parameters are unaffected by a broad class of noise models, such as measurement noise, gate noise, and Pauli channel noise. Furthermore, our numerical implementations on IBM's noisy simulator demonstrate resilience when compiling the quantum Fourier transform, Toffoli gate, and W-state preparation. Hence, variational quantum compiling, due to its robustness, could be practically useful for noisy intermediate-scale quantum devices.

Speaker: **Chenglong You** (Louisiana State University)
Title: *Identification of light sources using machine learning*
Abstract: The identification of light sources represents a task of utmost importance for the development of multiple photonic technologies. Over the last decades, the identification of light sources as diverse as sunlight, laser radiation and molecule fluorescence has relied on the collection of photon statistics or the implementation of quantum state tomography. In general, this task requires an extensive number of measurements to unveil the characteristic statistical fluctuations and correlation properties of light, particularly in the low-photon flux regime. In this talk, we exploit the self-learning features of artificial neural networks and naive Bayes classifier to dramatically reduce the number of measurements required to discriminate thermal light from coherent light at the single-photon level. We demonstrate robust light identification with tens of measurements at mean photon numbers below one. Our work demonstrates an improvement in terms of the number of measurements of several orders of magnitude with respect to conventional schemes for characterization of light sources. Our work has important implications for multiple photonic technologies such as LIDAR and microscopy.