QuILT Day
Wednesday, May 30, 2018

SCHEDULE

*Schedule: 9am–10:30am, talks
10:30am–11am break
11am–12pm, talks
12pm–1:30pm lunch
1:30pm–3pm, talks
3pm–3:30pm, break
3:30pm–5pm, talks

MEETING ROOM

All lectures will be held in Rm 242, Boggs Center for Energy and Biotechnology. A projector and a blackboard are available for presentations.

PROGRAM

9:00–9:30	Erin Knutson — Multi-spatial-mode nonlinear optical phenomena for use in continuous-variable quantum optics
9:30–10:00	Victor Bankston — Quantum contextuality and graph theory
10:00–10:30	Eneet Kaur — Extendibility limits the performance of quantum processors
10:30–11:00	Coffee Break (PJs on ground level)
11:00–11:30	Noah Davis — Broadcast amplitude damping channel for quantum communication
11:30–12:00	Sanjaya Lohani — Machine learning for classical and quantum communications
12:00–13:30	Lunch Break
13:30–14:00	Kunal Sharma — Bounding the energy-constrained quantum and private capacities of phase-insensitive bosonic Gaussian channels
14:00–14:30	Vladimir Zamdzhiev — Baby's first diagrammatic calculus for quantum information processing
14:30–15:00	Kevin Valson Jacob — Quantum process tomography of linear and quadratically non-linear optical systems
15:00–15:30	Coffee Break (PJs on ground level)
15:30–16:00	Sumeet Khatri — Robust quantum network architectures and topologies for entanglement distribution
16:00–17:00	Break-out discussion / poster session

QuILT Day
May 30, 2018

ABSTRACTS
(in alphabetical order by speaker surname)

Speaker: **Victor Bankston** (Tulane University)
Title: *Quantum Contextuality and Graph Theory*
Abstract: Bell's Inequality is an eerie example of the discrepancy between classical and quantum probabilities. The more general phenomenon has been dubbed contextuality. We will present a framework for understanding contextuality which represents experiments via a graph. The independence number of this graph is a bound on the correlations which can be achieved classically, while the Lovasz number is a bound on the correlations which can be achieved in the quantum setting. We will present some examples using Sage.

Speaker: **Noah Davis** (Louisiana State University)
Title: *The Broadcast Amplitude Damping Channel for Quantum Communication*
Abstract: An amplitude damping channel may be used to describe many natural effects, such as the decay of a two-level system or the loss of a photon to the environment. We develop a model of an amplitude damping channel in a broadcast setting, in which there is a single sender and multiple receivers. We briefly examine broadcast channels in general before specifically considering a broadcast amplitude damping channel and its capacities for transmitting classical, private, and quantum information. Finally, we determine bounds on these capacities using entropy and information measures.

Speaker: **Kevin Valson Jacob** (Louisiana State University)
Title: *Quantum process tomography of linear and quadratically nonlinear optical systems*
Abstract: A central task in quantum information processing is to characterize quantum processes. In the realm of optical quantum information processing, this amounts to characterizing the transformations of the mode creation and annihilation operators. This transformation is unitary for linear optical systems, whereas these yield the well-known Bogoliubov transformations for systems with Hamiltonians that are quadratic in the mode operators. In this paper, we show that a modified Mach-Zehnder interferometer can characterize both these kinds of evolutions for multimode systems. While it suffices to use coherent states for the characterization of linear optical systems, we additionally require single photons to characterize quadratically nonlinear optical systems.

Speaker: **Eneet Kaur** (Louisiana State University)
Title: *Extendibility limits the performance of quantum processors*
Abstract: Resource theories in quantum information science are helpful for the study and quantification of the performance of information-processing tasks that involve quantum systems. These resource theories also find applications in the study of other areas; e.g., the resource theories of entanglement and coherence have found use and implications in the study of quantum thermodynamics and memory effects in quantum dynamics. In this work, we introduce the resource theory of unextendibility, which is associated to the inability of extending quantum entanglement in a given quantum state to multiple parties. The free states in this resource theory are the k-extendible states, and the free channels are k-extendible channels, which preserve the class of k-extendible states. We make use of this resource theory to derive non-asymptotic, upper bounds on the rate at which quantum communication or entanglement preservation is possible by utilizing an arbitrary quantum channel a finite number of times, along with the assistance of k-extendible channels at no cost. We then show that the bounds we obtain are significantly tighter than previously known bounds for both the depolarizing and erasure channels.

Speaker: **Sumeet Khatri** (Louisiana State University)
Title: *Robust quantum network architectures and topologies for entanglement distribution*
Abstract: Entanglement distribution is a prerequisite for several important quantum information processing and computing tasks, such as quantum teleportation, quantum key distribution, and distributed quantum computing. In this work, we focus on two-dimensional quantum networks based on optical quantum technologies using dual-rail photonic qubits for the building of a fail-safe quantum internet. We lay out a quantum network architecture for entanglement distribution between distant parties using a Bravais lattice topology, with the technological constraint that quantum repeaters equipped with quantum memories are not easily accessible. We provide a robust protocol for simultaneous entanglement distribution between two distant groups of parties on this network. We also discuss a memory-based quantum network architecture that can be implemented on networks with an arbitrary topology. We examine networks with bow-tie lattice and Archimedean lattice topologies and use percolation theory to quantify the robustness of the networks. In particular, we provide figures of merit on the loss parameter of the optical medium that depend only on the topology of the network and quantify the robustness of the network against intermittent photon loss and intermittent failure of nodes. These figures of merit can be used to compare the robustness of different network topologies in order to determine the best topology in a given real-world scenario, which is critical in the realization of the quantum internet.

Speaker: **Erin Knutson** (Tulane University)
Title: *Multi-spatial-mode nonlinear optical phenomena for use in continuous-variable quantum optics*
Abstract: Working in the regime of continuous variables allows for the generation of robust quantum states of light, near-unity detection efficiency, and avoids the technical difficulties surrounding single-photon counting. Here I will discuss three recent experimental projects wherein we have used a hot atomic vapor cell as a nonlinear tool to create new and useful spatially non-Gaussian states of light that are useful in the continuous-variable regime. Notably, we demonstrate Bessel-Gauss-like beams that possess a high degree of self-reconstructive ability, as well as two new four-wave mixing (FWM) configurations: one which results in multiple spatially- and temporally-correlated modes and another that sheds light on the optimally-entangled FWM output of experiments involving multiple pump beams.

Speaker: **Sanjaya Lohani** (Tulane University)
Title: *Machine learning for classical and quantum communications*
Abstract: Optical communication relies on the generation, transmission, and detection of states of light to encode and send information. While numerous protocols have been devised in order to increase the information transfer rate in optical communication scenarios, making use of the orbital angular momentum (OAM) degree of freedom of light is arguably one of the most promising methods. Here, we demonstrate the ability of Machine Learning (ML) techniques to efficiently differentiate simultaneously between numerically generated OAM states that have from 1 to 100 quanta of OAM with near-unity fidelity, even in the presence of substantial noise. We also show that this technique can differentiate between numerous experimentally generated superpositions of OAM modes with nearly perfect accuracy, when the ML networks are trained using only simulated images. Additionally, we present neural network results applied to turbulence-correction of optical modes. The neural-network corrected optical mode profiles at the receiver of a communications platform, after propagating through significant turbulence, are found to be nearly identical to the desired profiles, with near-zero mean square error indices. Finally, we discuss about how we may detect and accurately classify Phase Shifted Keys (PSK) at the receiver with ML. We are hopeful that the present results combining the fields of ML and optical communications will greatly enhance the robustness of free space classical and quantum optical links.

Speaker: **Kunal Sharma** (Louisiana State University)
Title: *Bounding the energy-constrained quantum and private capacities of phase-insensitive bosonic Gaussian channels*
Abstract: We establish several upper bounds on the energy-constrained quantum and private capacities of

all phase-insensitive Gaussian channels. The first upper bound, which we call the "data-processing bound," is the simplest and is obtained by decomposing a phase-insensitive channel as a pure-loss channel followed by a quantum-limited amplifier channel. We prove that the data-processing bound can be at most 1.45 bits larger than a known lower bound on these capacities of the phase-insensitive Gaussian channel. We discuss another data-processing upper bound as well. Two other upper bounds, which we call the "ε-degradable bound" and the "ε-close-degradable bound," are established using the notion of approximate degradability along with energy constraints. We find a strong limitation on any potential superadditivity of the coherent information of any phase-insensitive Gaussian channel in the low-noise regime, as the data-processing bound is very near to a known lower bound in such cases. We also find improved achievable rates of private communication through bosonic thermal channels, by employing coding schemes that make use of displaced thermal states. We end by proving that an optimal Gaussian input state for the energy-constrained, generalized channel divergence of two particular Gaussian channels is the two-mode squeezed vacuum state that saturates the energy constraint. What remains open for several interesting channel divergences, such as the diamond norm or the Rényi channel divergence, is to determine whether, among all input states, a Gaussian state is optimal.

Speaker: **Vladimir Zamdzhiev** (Tulane University)
Title: *Baby's first diagrammatic calculus for quantum information processing*
Abstract: This talk is a basic introduction to the ZX-calculus, a diagrammatic calculus for quantum information processing that was recently shown to be complete for pure state quantum mechanics and can therefore be seen as an alternative to the traditional Hilbert space formalism.