QuILT Day
Friday, July 19, 2019

MEETING ROOM

All lectures will be held in Rm 435 on the fourth floor of Nicholson Hall (LSU Department of Physics and Astronomy). A projector and a whiteboard are available for presentations.

PROGRAM

9:30–10:00	Margarite LaBorde — Diagnosing gate failures in quantum circuits with machine learning
10:00–10:30	Kahlil Dixon — Single cavity ponderomotive entanglement
10:30–11:00	Coffee Break
11:00–11:30	Christopher Vairogs — Quantum state discrimination circuits inspired by Deutschian closed timelike curves
11:30–12:15	Mark M. Wilde — Resource theory of asymmetric distinguishability
12:15–14:00	Lunch Break (Walk to Newk's Eatery, 3332 Lake St)
14:00–14:30	Rachel Soto-Garcia — Evaluating the automatic classification of a Laguerre–Gaussian mode using deep convolutional neural networks
14:30–15:15	Thomas Corbitt — Quantum opto-mechanics with micromirrors
15:15–15:45	Coffee Break
15:45–16:15	Aliza Siddiqui — Computationally evaluating robustness of quantum networks
16:15–16:45	Erin Knutson — Seeded and unseeded four-output four-wave mixing

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ABSTRACTS
(in alphabetical order by speaker surname)

Speaker: **Thomas Corbitt** (Louisiana State University)
Title: *Quantum opto-mechanics with micromirrors*
Abstract: I'll talk about a series of cavity optomechanics experiments that we've performed with micromirrors. These experiments measure quantum back action on a macroscopic objects, which allows for testing of experimental techniques to reduce the impact of the back action noise. This is especially applicable to gravitational wave interferometers, including Advanced LIGO and Virgo.

Speaker: **Kahlil Dixon** (Louisiana State University)
Title: *Single cavity ponderomotive entanglement*
Abstract: Entanglement is a critical resource in all quantum technological applications. Optome- chanical methods of generating entangled photons are gaining attention. Our research attempts to turn a significant source of noise in optical applications (such as LIGO) into a source for entangled photons; these sources are due to ponderomotive effects. Our simulations, and eventually experiment, will measure the entanglement between two light fields via an optical spring cavity system; this system uses a micromirror to enhance the systems sensitivity to ponderomotive noise. The effect of the ponderomotive forces on the micromirror should entangle the output fields. The entangling process can be mathematically described by the quantum Langevin equations. Entanglement will be measured using the logarithmic negativity (EN) extracted from the variance matrix. Other methods for quantifying and measuring entanglement in the system are explored. Temperature and other lab parameters are optimized to achieve the highest possible entanglement.

Speaker: **Erin Knutson** (Tulane University)
Title: *Seeded and unseeded four-output four-wave mixing*
Abstract: We demonstrate unseeded multimode four-wave mixing wherein each created photon is correlated to exactly two others, resulting in an "optimal" four-mode output. The generated beams are spatially separated, readily allowing for use in optical communications protocols. We also show preliminary results of seeding the configuration to achieve a phase-sensitive amplifier without homodyning or cascading and with only two input frequencies.

Speaker: **Margarite LaBorde** (Louisiana State University)
Title: *Diagnosing gate failures in quantum circuits with machine learning*
Abstract: We propose a method of identifying a faulty gate in a given quantum circuit using hybrid K-Nearest-Neighbors (KNN) machine learning technique. This is accomplished by using a diagnostic circuit and selected input qubits to obtain the fidelity between output states of the altered circuit and a set of given reference states, providing a quantum analogy to the Euclidean distances used for KNN classification algorithms. The outcomes of the quantum circuit can then be stored to be used for a classical KNN algorithm. We demonstrate numerically an ability to locate a faulty gate in circuits with over 30 gates and up to 11 qubits with over 90% accuracy.

Speaker: **Aliza Siddiqui** (Louisiana State University)
Title: *Computationally evaluating robustness of quantum networks*
Abstract: Before global-scale quantum networks become operational, it is important to consider how to evaluate their performance, so that they can be suitably built to achieve the desired performance. In this

talk, I will discuss the three figures of merit that we consider for the performance of a quantum network: the average global connection time, the average point-to-point connection time, and the average largest entanglement cluster size. These three quantities are based on the generation of elementary links in a quantum network, which is a crucial initial requirement that must be met before any long-range entanglement distribution can be achieved. We evaluate these figures of merit for a particular class of quantum repeater protocols consisting of repeat-until-success elementary link generation along with entanglement swapping at intermediate nodes in order to achieve long-range entanglement. I will also discuss how I determined the robustness of a quantum network tree in which several parties attempt communication with a target node with third party interference, instead of simple node-to-node communication.

Speaker: **Rachel Soto-Garcia** (Rensselaer Polytechnic Institute)
Title: *Evaluating the automatic classification of a Laguerre–Gauss mode using deep convolutional neural networks*
Abstract: One of the methods to transfer information is using optical communications, such as Laguerre Gaussian Modes and their superpositions. In reality, we cannot have clean images in experimental due to different sources of noises such as Interference fringes, dust particles, and lopsided intensity. The problem is more severe when we specifically working with higher modes. In this project, we demonstrate the ability to use a deep neural network, specifically convolutional neural network to classify the experimental images of Laguerre-Gauss modes. Our setup includes the images of the intensity for 14 different modes with L=0,1,2,3 and G=0,1,2,3 each of them about 1000 images.

Speaker: **Christopher Vairogs** (University of Florida)
Title: *Quantum state discrimination circuits inspired by Deutschian closed timelike curves*
Abstract: The Holevo-Helstrom theorem places a bound on the probability of perfectly distinguishing two non-orthogonal states in a single measurement. However, using quantum states traveling along a Closed Timelike Curve (CTC), one can perfectly distinguish multiple non-orthogonal states and violate the Heisenberg uncertainty principle. A quantum computer can simulate a CTC using a quantum memory, multiple copies of the input state, and multiple iterations of a quantum channel. We show that the probability of correctly distinguishing states with the CTC-inspired scheme converges exponentially to one with respect to the number of iterations, leading to a method for practical state discrimination. We then explore several applications of this scheme, which may lead to table-top experiments.

Speaker: **Mark M. Wilde** (Louisiana State University)
Title: *Resource theory of asymmetric distinguishability*
Abstract: In this talk, I will discuss the resource theory of asymmetric distinguishability, as initiated roughly a decade ago [arXiv:1006.0302] and developed further recently in [arXiv:1905.11629]. The key constituents of this resource theory are quantum boxes, consisting of a pair of quantum states, which can be manipulated for free by means of an arbitrary quantum channel. We introduce bits of asymmetric distinguishability as the basic currency in this resource theory, and we prove that it is a reversible resource theory in the asymptotic limit, with the quantum relative entropy being the fundamental rate of resource interconversion. The distillable distinguishability is the optimal rate at which a quantum box consisting of independent and identically distributed (i.i.d.) states can be converted to bits of asymmetric distinguishability, and the distinguishability cost is the optimal rate for the reverse transformation. Both of these quantities are equal to the quantum relative entropy. The exact one-shot distillable distinguishability is equal to the Petz–Rényi relative entropy of order zero, and the exact one-shot distinguishability cost is equal to the max-relative entropy. Generalizing these results, the approximate one-shot distillable distinguishability is equal to the hypothesis testing relative entropy, and the approximate one-shot distinguishability cost is equal to the smooth max-relative entropy. As a notable application of the former results, we prove that the optimal rate of asymptotic conversion from a pair of i.i.d. quantum states to another pair of i.i.d. quantum states is fully characterized by the ratio of their quantum relative entropies. Joint work with Xin Wang (University of Maryland).