# QuILT Day
# Tuesday, April 20, 2021

### MEETING ROOM

All presentations from 9:00am–4:10pm CDT will be held online on Zoom:

`https://lsu.zoom.us/j/97917788529?pwd=WDE1bTFob2tDK0FyZVNTRUthbndqQT09`

### PROGRAM

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| **9:00–9:30** | Aliza Siddiqui — Quantifying the performance of bidirectional quantum teleportation |
| **9:35–10:05** | Rongying Jin — Materials frontiers to advance quantum information science |
| **10:05–10:20** | Break |
| **10:20–10:50** | Sander Uijlen — |
| **10:55–11:25** | Peter Bierhorst — Ruling out bipartite nonsignaling nonlocal models for tripartite correlations |
| **11:30–12:00** | Ilya Vekhter — Topological interfaces: the good, the bad, and the ugly |
| **12:00–13:00** | Lunch Break |
| **13:00–13:30** | Mingyuan Hong — Observation of the modification of quantum statistics of plasmonic systems |
| **13:35–14:05** | Dustin Lindberg — |
| **14:05–14:20** | Break |
| **14:20–14:50** | Arshag Danageozian — Noisy coherent population trapping: Applications to noise estimation and qubit state preparation |
| **14:55–15:25** | Anthony Brady — Stimulating the quantum aspects of an analogue white-black hole |
| **15:25–15:40** | Break |
| **15:40–16:10** | Ravi Saripalli — All-optical input-agnostic polarization transformer |

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## ABSTRACTS
### (in alphabetical order by speaker surname)

Speaker: **Peter Bierhorst** (University of New Orleans)
Title: *Ruling out bipartite nonsignaling nonlocal models for tripartite correlations*
Abstract: Many three-party correlations, including some that are commonly described as genuinely tripartite nonlocal, can be simulated by a network of underlying subsystems that display only bipartite nonsignaling nonlocal behavior. Quantum mechanics predicts three-party correlations that admit no such simulation, suggesting there are versions of nonlocality in nature transcending the phenomenon of bipartite nonsignaling nonlocality. In this talk, I'll discuss my recent paper (arxiv.org/abs/2012.11132) that introduces a rigorous framework for analyzing tripartite correlations that can be simulated by bipartite-only networks. We confirm that expected properties of so-obtained correlations, such as no-signaling, indeed hold, and show how to use the framework to derive Bell-inequality-type constraints on these correlations that can be robustly violated by tripartite quantum systems. In particular, we can use this framework to rederive a version of one such constraint previously described in a paper of Chao and Reichardt (arXiv:1706.02008).

Speaker: **Anthony Brady** (Louisiana State University)
Title: *Stimulating the quantum aspects of an analogue white-black hole*
Abstract: The Hawking effect was originally discovered in the astrophysical context of the spontaneous decay of black holes into blackbody radiation, i.e., Hawking radiation. However, this effect seems to be universal, appearing anywhere that an effective event horizon forms. Here, we consider the Hawking effect in an optical-analogue gravity context, building on prior theoretical results regarding this effect in dielectric media. In particular, we analyze the pair-creation process of an analogue white-hole–black-hole pair (a white-black hole) which share an interior region and provide a simplification of the relevant scattering processes via the Bloch-Messiah reduction. With this simplification and leveraging the positivity of partial transpose (PPT) criteria, we examine the quantum correlations generated by the white-black hole, quantitatively showing that an environmental background temperature can destroy entanglement between various subsystems, even when the Hawking temperature of the white-black hole is comparatively large. We also discuss the prospect of enhancing and "reviving" entanglement pre-mortem using a single-mode, non-classical resource at the input. Though much of the discussion is phrased in terms of an optical-analogue model, the methods used and results obtained apply just as well to a variety of other systems supporting this effect.

Speaker: **Arshag Danageozian** (Louisiana State University)
Title: *Noisy coherent population trapping: Applications to noise estimation and qubit state preparation*
Abstract: Coherent population trapping is a well-known quantum phenomenon in a driven ? system, with many applications across quantum optics. However, when a stochastic bath is present in addition to vacuum noise, the observed trapping is no longer perfect. Here we derive a time-convolutionless master equation describing the equilibration of the ? system in the presence of additional temporally correlated classical noise, with an unknown decay parameter. Our simulations show a one-to-one correspondence between the decay parameter and the depth of the characteristic dip in the photoluminescence spectrum, thereby enabling the unknown parameter to be estimated from the observed spectra. We apply our analysis to the problem of qubit state initialization in a ? system via dark states and show how the stochastic bath affects the fidelity of such initialization as a function of the desired dark-state amplitudes. We show that an optimum choice of Rabi frequencies is possible.

Speaker: **Mingyuan Hong** (Louisiana State University)

Title: *Observation of the modification of quantum statistics of plasmonic systems*

Abstract: For almost two decades, it has been believed that the quantum statistical properties of bosons are preserved in plasmonic systems. This idea has been stimulated by experimental work reporting the possibility of preserving nonclassical correlations in light-matter interactions mediated by scattering among photons and plasmons. Furthermore, it has been assumed that similar dynamics underlies the conservation of the quantum fluctuations that the define the nature of light sources. Here, we demonstrate that quantum statistics are not always preserved in plasmonic systems and report the first observation of their modification. Moreover, we show that multiparticle scattering effects induced by confined optical near fields can lead to the modification of the excitation mode of plasmonic systems. These observations are validated through the quantum theory of optical coherence for single- and multi-mode plasmonic systems. Our findings represent a paradigm shift in the understanding of the quantum properties of plasmonic systems. We believe that our work unveils new paths to perform exquisite control of quantum multiparticle systems.

Speaker: **Rongying Jin** (Louisiana State University)

Title: *Materials Frontiers to Advance Quantum Information Science*

Abstract: The interaction between quantum materials and quantum information science has been a triumph over the past decade, and is exploding into quantum technology. In my talk, I will briefly introduce some unique properties of quantum materials (e.g., Weyl semimetals and single- molecule toroidal materials) that are promising for quantum device applications.

Speaker: **Ravi Saripalli** (Tulane University)

Title: *All-optical input-agnostic polarization transformer*

Abstract: The polarization of light is utilized in many technologies throughout science and engineering. In particular, many quantum information protocols make use of the polarization degree-of-freedom. The ability to transform one state of polarization to another is a key enabling technology. Common polarization transformers are simple polarizers and polarization rotators. Simple polarizers change the intensity depending on the input state and can only output a fixed polarized state, while polarization rotators rotates the input Stokes vector in the 3D Stokes space. We demonstrate an all-optical input-agnostic polarization transformer (AI-APT), which transforms all input states of polarization to a particular state that can be polarized or partially polarized. The output state of polarization and intensity depends solely on setup parameters, and not on the input state, thereby the AI-APT functions differently from simple polarizers and polarization rotators. The AI-APT is completely passive, and thus can be used as a polarization controller or stabilizer for single photons and ultrafast pulses. The AI-APT may open a new frontier of partially polarized ultrafast optics.

Speaker: **Aliza Siddiqui** (Louisiana State University)

Title: *Quantifying the performance of bidirectional quantum teleportation*

Abstract: Bidirectional teleportation is a fundamental protocol for exchanging quantum information between two parties by means of a shared resource state and local operations and classical communication (LOCC). In this paper, we develop two seemingly different ways of quantifying the simulation error of unideal bidirectional teleportation by means of the normalized diamond distance and the channel infidelity, and we prove that they are equivalent. By relaxing the set of operations allowed from LOCC to those that completely preserve the positivity of the partial transpose, we obtain semi-definite programming lower bounds on the simulation error of unideal bidirectional teleportation. We evaluate these bounds for three key examples: when there is no resource state at all and for isotropic and Werner states, in each case finding an analytical solution. The first aforementioned example establishes a benchmark for classical versus quantum bidirectional teleportation. We then evaluate the performance of some schemes for bidirectional teleportation due to [Kiktenko *et al.*, Phys. Rev. A 93, 062305 (2016)] and find that they are suboptimal and do not go beyond the aforementioned classical limit for bidirectional teleportation. We offer a scheme alternative to theirs that is provably optimal. Finally, we generalize the whole development to the setting of bidirectional controlled teleportation, in which there is an additional assisting party who helps with the exchange of quantum information, and we establish semi-definite programming lower bounds on the simulation error for this task. More generally, we provide semi-definite programming lower bounds on the performance of bipartite and multipartite channel simulation using a shared resource state and LOCC.

Speaker: **Ilya Vekhter** (Louisiana State University)
Title: *Topological interfaces: the good, the bad, and the ugly*
Abstract: Topological materials have been suggested as the main building block for technologies underlying next generation quantum devices. However, the details of what happens at the interfaces of topological materials and their non-topological counterparts are still not fully understood beyond simplest models. I will briefly describe our recent work on interfaces between topological materials and semiconductors, ferromagnets, and superconductors, that aims to build the predictive framework for the description of topological interfaces. I will argue that a much wider variety of behaviors than what is usually assumed can occur in such systems, and indicate pathways to controlling the desired properties.