Grad Student Conference Titles and Abstracts

Barbara, Jinmin

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1 Shayan Majidy, University of Waterloo, IQC

Title: Noncommuting charges: Bridging theory to experiment

Abstract: Noncommuting conserved quantities have recently launched a subfield of quantum thermodynamics. In conventional thermodynamics, a system of interest and an environment exchange quantities– energy, particles, electric charge, etc.– that are globally conserved and are represented by Hermitian operators. These operators were implicitly assumed to commute with each other, until a few years ago. Freeing the operators to fail to commute has enabled many theoretical discoveries – about reference frames, entropy production, resource-theory models, etc. Little work has bridged these results from abstract theory to experimental reality. This work provides a methodology for building this bridge systematically: we present a prescription for constructing Hamiltonians that conserve noncommuting quantities globally while transporting the quantities locally. The Hamiltonians can couple arbitrarily many subsystems together and can be integrable or nonintegrable. Our Hamiltonians may be realized physically with superconducting qudits, with ultracold atoms, and with trapped ions
reminder for registration

2 Johanna Borissova, Perimeter Institute, University of Waterloo

Title: Dynamics of black holes in asymptotically safe quantum gravity
Abstract: Quantum counterparts to classical black holes provide an exciting ground for phenomenology of quantum gravity. Within the functional renormalization group approach to quantum gravity, we propose a novel method to account for quantum effects in classical spacetimes. At the core of our construction is decoupling mechanism: when a physical low-energy scale overcomes the effect of the artificial regulator implementing the Wilsonian integration of fluctuating modes, the effective average action freezes out and approximates the standard quantum effective action. Starting from the Einstein-Hilbert truncation, we use the decoupling mechanism to explore the dynamics of quantum black holes in the stages of collapse and evaporation.

3 Barbara Šoda, Perimeter Institute, University of Waterloo

Title: Newton's cradle spectra

Abstract: We present broadly applicable nonperturbative results on the behavior of eigenvalues and eigenvectors under the addition of self-adjoint operators and under the multiplication of unitary operators, in finite-dimensional Hilbert spaces. To this end, we decompose these operations into elementary 1-parameter processes in which the eigenvalues move similarly to the spheres in Newton's cradle. As special cases, we recover level repulsion and Cauchy interlacing. We discuss two examples of applications. Applied to adiabatic quantum computing, we obtain new tools to relate algorithmic complexity to computational slowdown through gap narrowing. Applied to information theory, we obtain a generalization of Shannon sampling theory, the theory that establishes the equivalence of continuous and discrete representations of information. The new generalization of Shannon sampling applies to signals of varying information density and finite length.

4 Ding Jia, Perimeter Institute, University of Waterloo

Title: Modes of experience in a superposed world

Abstract: A central open problem of quantum physics is to reconcile theory with experience. In this work I present a framework for studying distinct modes of experience in a superposed world. A mode of experience is characterized by how the world, experiences, and options relate to each other by the perceptions, decisions, and actions, as well as by probabilistic rules encoding probabilistic or deterministic correlations among first person experiences. In a toy model, the life expectancies of beings in different candidate modes of experience are compared. It is found that the quantum mode without macroscopic superposition outlives that with macroscopic superposition and that with real amplitudes. These highlight the prospect to explain a mode of experience by its evolutionary advantages.

5 Amalia Madden, Perimeter Institute

Title: New force QCD axion

Abstract: TBA

6 Jose Polo Gomez, University of Waterloo, IQC

Title: Measuring quantum fields with particle detectors and machine learning

Abstract: The model for measurements used in quantum mechanics (based on the projection postulate) cannot be extended to model measurements of quantum fields, since they are incompatible with relativity. We will see that measurements performed with particle detectors (i.e., localized non-relativistic quantum systems that couple covariantly to quantum fields) are consistent with relativity, and that they allow us to build a consistent measurement theory for QFT. For this measurement framework to be of practical use, we need to understand how can we measure specific properties of the field using a particle detector. I will show that there is a simple fixed measurement protocol that allows us to extract essentially all the information about the field that the detector gathers, and that this information can then be interpreted to study a specific targeted feature using machine learning techniques. Specifically, I will examine two examples in which we use a neural network to extract global information about the field (boundary conditions and temperature) performing local measurements, taking advantage of the fact that this global information is stored locally by the field, albeit in a scrambled way.

7 Francisco Borges, Perimeter Institute, McMaster University

Title: Superconductivity from the antiferromagnetic quantum critical metal in two dimensions

Abstract: To describe the full universal low-energy physics of metals, it is necessary to include all gapless modes around the Fermi surface. In this talk, we study the non-Fermi liquid state that arises at the antiferromagnetic quantum critical point in two space dimensions through a novel field-theoretic functional renormalization group scheme. In this theory, critical spin fluctuations destroy the coherence of single-particle states close to strongly interacting points on the Fermi surface and at the same time, they provide the attractive glue that results in pairing instability. The interplay between these pair-breaking and pair-forming effects controls the quasi-universal pathway from the non-Fermi liquid state to the superconductive state.

8 Aiden Suter, Perimeter Institute

Title: Chiral deformation quantization

Abstract: In this talk I will give a brief overview of a generalisation of Fedosov quantization, a type of deformation quantization, to the chiral setting.

In particular I will outline a geometric approach to chiral quantization using Gelfand-Khazdan formal geometry, introduced by Gorbounov, Gwilliam and Williams, which makes use of the fact that the local observables of the curved beta-gamma system encode the sheaf of chiral differential operators used in chiral quantization. If time permits I will mention some potential applications and further generalisations of this procedure.

9 Himanish Ganjoo, Perimeter Institute

Title: Signatures of Hidden Sectors from the Early Universe
Abstract: Particle physics and direct detection experiments have yielded null results for dark matter. As a result, interest is growing in theories in which dark matter lives in a hidden sector coupled only weakly to the Standard Model. Many hidden sector theories involve an epoch of matter domination in the very early Universe, deviating from the story of standard Lambda-CDM cosmology. Dark matter perturbations grow faster in matter domination than they would in radiation domination, leading to early formation of dense microhalos. These microhalos boost the possible annihilation signal from dark matter and could be detected via pulsars and microlensing in clusters. Modeling the distribution of these microhalos is key to constraining hidden-sector cosmologies with early matter domination. My work analyses how the properties of the hidden sector affect the formation of microhalos and the observables resulting from them. Specifically, I model how relativistic particles in the hidden sector impact microhalo formation, in addition to performing simulations of how these microhalos form, survive and get destroyed in the early Universe.

10 Taillte May, Perimeter Institute,

Title: The search for new particles using black hole superradiance

Abstract: There is theoretical motivation for particles beyond those we have so far discovered. Our observations of the universe suggest there must be some 'dark matter' or matter whose content we don't understand. Bosons with very small mass (10^{-13}eV) can form oscillating clouds around black holes. These clouds would emit gravitational waves. Here, I'll present some developments of theoretical predictions of this gravitational wave signal. Detection of this signal would provide evidence for the existence of new particles. This kind of search is complimentary to lab experiment searches.

11 Justin Kulp, Perimeter Institute

Title: Holomorphic Twists of SUSY QFTs

Abstract: SUSY QFT's are of long-standing interest for their high degree of solvability (due in part to the power of BPS quantities) and phenomenological implications. The holomorphic twist produces a new theory which precisely isolates the BPS operators which give the SUSY QFT its potency. I will describe how this twist is performed; the algebraic structure of the twisted theory; and three surprising results about interacting theories, Feynman diagrams, and confinement.

12 Jordan Krywonos, Perimeter Institute

Title: Testing the Robustness of Statistical Inference for Cosmological Parameter Measurements

Abstract: Cosmological models are used to describe our universe and their free parameters can be constrained by observations. However, these constraints are reliant on the precision of our data analysis. A major issue in cosmology is that high- and low-redshift measurements significantly disagree on the value of certain parameters, such as the Hubble constant H0. By improving our statistical analysis, these types of tensions can be relieved. We investigate the robustness of concordance cosmology to assumptions made about the data, such as the choice of prior used in Bayesian analysis. The measurements we stress test are the Cosmic Microwave Background (CMB) and Baryon Acoustic Oscillation (BAO). Through changing the form of the prior, we find that both the parameter's mean value and error bars can depend considerably on this choice. The optical depth of reionization, , is the most sensitive to these changes. It also affects tensions surrounding dataset values of S8 (the weighted amplitude of matter fluctuations) and H0. This altogether highlights how constraints are subjective to statistical inference.

13 Vincent Chen, Perimeter Institute

Title: Viewing asymptotic symmetries through conformal mappings
Abstract: Over the past decade, many infrared phenomena of gauge theories, such as soft theorems and memory effects, have been shown to be manifestations of asymptotic symmetries which persist to the spacetime boundary. In this talk, I will discuss ongoing work, in collaboration with Robert Myers and Ana-Maria Raclariu, which recasts the asymptotic symmetries of gauge theories in Minkowski spacetime through conformal mappings. Through a mapping to the Einstein static universe, I will describe how conservation of asymptotic charge can be viewed as a smoothness constraint for image sources passing through spacelike infinity. Additionally, I will sketch how asymptotic charge flux through a subregion of null infinity is mapped to edge modes. This will then allow us to quantify fluctuations in asymptotic charge flux by relation to edge mode entropies, which have been well-studied in literature. Altogether, the general

theme of my talk will be how new insights can be obtained by conformally mapping asymptotic structures of gauge theories to various settings.

14 Caroline de Lima, Perimeter Institute

Title: New insights on the weight of entanglement
Abstract: While we do not have a final theory of quantum gravity, we have learned valuable lessons from investigations on how gravity affects quantum properties of matter and vice versa. In this talk, I will review a paper that claims that entangled and separable states affect spacetime curvature differently. I will present the proposed setup and show a particular case. Then, I will argue that the framework on which the conclusions are based does not suffice to tackle this problem as originally designed.