2025 Theory Canada 17

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Book of Abstracts

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Nuclear Physics / 1

Electromagnetic radiation from jet-medium interactions in the Quark-Gluon Plasma

Authors: AMIT KUMAR[1]; Gojko Vujanovic[2]

[1] *Department of Physics, University of Regina Canada*

[2] *University of Regina*

Corresponding Author: amit.kumar@uregina.ca

Ultra-relativistic heavy-ions collisions performed at the Relativistic Heavy-Ion Collider (RHIC) and the Large Hadron Collider (LHC) produce a deconfined state of quarks and gluons, called the quark-gluon plasma (QGP). One of the primary goals of these collisions is to infer the properties of the QGP through the modifications it imparts on the evolution of high-energy quarks and gluons (also known as hard partons) in the QGP. At early times following a heavy-ion collision, partons are produced in a highly excited (i.e. highly virtual) state and undergo energy loss via bremsstrahlung radiation. At later times, multiple scatterings in the QGP become the dominant mechanism of parton energy loss. To better understand the dynamics of the parton energy loss, we focus on the production of photons from the highly virtual hard quarks traversing the QGP. In prior efforts, scattering rates have been computed for the case of gluon bremsstrahlung off from a highly virtual quark traversing the QGP. To minimize hadronization uncertainties, the present study focuses on photon emission rates. Photons avoid hadronization effects and provide an independent probe to constrain the parton energy loss transport coefficients.

We used the generalized factorization procedure, employed in the e-A deep-inelastic scattering, to derive an improved single emission and single scattering collision kernel for photon production, going beyond traditional in-medium gluon exchange approximation. We identified two types of scattering kernels at $O(\alpha_{em}\alpha_s)$ giving the following final states: (i) real photon and real quark, (ii) real photon and real gluon. We will present these scattering kernels [1] and argue that a better way to extract properties of the QGP is to simultaneously use photons and jets.

Reference:

(1) A. Kumar and G. Vujanovic, arXiv:2502.02667 (2025)

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Quantum Computing Education: Shaping Tomorrow's Workforce

Author: Shahpoor Moradi[None]

Corresponding Author: moradis@ucalgary.ca

As quantum computing advances, the demand for a highly skilled workforce is becoming increasingly urgent. Governments and industries worldwide are investing heavily in quantum technology, recognizing its potential to drive innovation and transform economies. However, the progress of this field depends not just on technological breakthroughs but also on the availability of professionals who can apply quantum principles to real-world problems.
Education plays a pivotal role in closing this talent gap. Developing effective quantum training programs is essential to prepare individuals for careers in research, industry, and emerging quantum startups. In this talk, I will discuss the necessity of quantum education in workforce development, the challenges in designing effective training programs, and how such initiatives can contribute to Canada's leadership in the global quantum economy. As an example, I will touch upon the University of Calgary's professional master's program in quantum computing, which is designed for both recent graduates and working professionals, focusing on the practical applications of quantum computing.

Condensed Matter Theory / 3

Properties of Holstein polarons at finite temperatures

Authors: Jeet Shannigrahi[1]; Mona Berciu[2]

[1] *University of British Columbia, Vancouver*

[2] *University of British Columbia*

Corresponding Authors: jeet.shannigrahi@gmail.com, berciu@phas.ubc.ca

We generalize the Momentum Average (MA) approximation to compute the finite temperature spectral functions of the Holstein polaron in a one-dimensional system. We validate our MA results in 1D against available numerical data from density matrix renormalization group (DMRG) and the finite-temperature Lanczos method, establishing the accuracy of the MA results which are obtained at a substantially lower computational cost. We use MA to to characterize the temperature range over which a coherent quasiparticle (the polaron) exists and we study the evolution with temperature of its effective mass and lifetime.

Relativity, Gravitation and Cosmology / 6

How the Schwarzschild–de Sitter horizons remain in thermal equilibrium at vastly different temperatures

Author: Valerio Faraoni[None]

Co-authors: Marcello Miranda [1]; Massimiliano Rinaldi [2]

[1] *U. Naples*

[2] *University of Trento*

Corresponding Authors: massimiliano.rinaldi@unitn.it, vfaraoni@ubishops.ca

The Tolman–Ehrenfest criterion of thermal equilibrium for a static fluid in a static spacetime is generalized to stationary heat conduction with negligible backreaction, and then applied to Hawking radiation in the Schwarzschild–de Sitter geometry. The two horizons acting as thermostats remain in thermal equilibrium. The temperature of the radiation fluid interpolates between those of the two horizons, with a static profile that is given explicitly.
[Based on M. Miranda, M. Rinaldi & V. Faraoni 2024, Phys. Rev. D 110, 104065 (arXiv:2409.12861)]

Condensed Matter Theory / 10

Topological Landau theory

Authors: Joseph Maciejko[1]; Canon Sun[1]

[1] *University of Alberta*

Corresponding Authors: maciejko@ualberta.ca, canon@ualberta.ca

I will discuss a notion of topology "hidden"in Landau's theory of phase transitions. When the order parameter comprises several components in the same irreducible representation of symmetry, it can possess a nontrivial topology and acquire a Berry phase under the variation of thermodynamic

parameters. To illustrate this idea, I will focus on the superconducting phase transition of an electronic system with tetragonal symmetry and an attractive interaction involving two partial waves, both transforming in the trivial representation. From the time-dependent Ginzburg-Landau equation in the adiabatic limit, we find that the order parameter acquires a Berry phase after a cyclic evolution of parameters. I will discuss two concrete models—one preserving time-reversal symmetry and one breaking it—and show that the nontrivial topology of the order parameter originates from thermodynamic analogs of gapless Dirac and Weyl points in the phase diagram. Finally, I will propose an experimental signature of the topological Berry phase in a Josephson junction.

Relativity, Gravitation and Cosmology / 11

Dark Matter @ Finite Temperature

Author: Saniya Saniya Heeba[1]

[1] *McGill University*

Corresponding Author: saniya.heeba@mcgill.ca

The microphysical properties of Dark Matter (DM), such as its mass and coupling strength, are typically assumed to retain their vacuum values when considering DM behaviour at a range of scales. However, DM interactions in different astrophysical and cosmological environments may be impacted by the properties of the background which in turn can substantially affect both DM production and the detection prospects for any given model. In the recent years, this has generated a lot of interest in calculating DM observables at finite temperature and density.

In this talk, I will provide an overview of what these effects are, and how they may give rise to new DM production mechanisms as well as impact observables.

Mathematical Physics / 12

Theoretical Non-linear dynamics analysis of stability of a bridge pier under two-phase turbulent flow

Author: Loïc NGOU ZEUFO[1]

[1] *Cégep Beauce-Appalaches*

Corresponding Author: ngouloic@yahoo.fr

Despite the development in Engineering, the structure such as bridge continue to collapse due to fluid loads effects. Their combination on a bridge pier can also induced catastrophic damages. Less attention in literature has been given to bridge pier dynamics under transversal flow. This work describes the dynamic vibration, including theoretical non-linear dynamics analysis, of a bridge pier under two-phase turbulent fluid flow. An overview of the description of a bridge pier and the different types of phase flow that can induce vibration in such a structure is presented. The external excitations due to two-phase flow are modelled first as two-frequency excitations, and secondly, for two-phase turbulent flow, the turbulence in the fluid load expression is given by independent unit Weiner processes. In both cases, the physical system is mathematically modelled as a non-linear partial differential equation. The mathematical framework, including Galerkin's method and some integrations taking good consideration of the space occupation of each phase of fluid flow along the beam, is developed to obtain the discrete general equation. To make the model more meaningful and practical, constant and parametric axial loads representing the bridge deck, taking into account their different states, are used in the modelling system. Using adequate analytical methods and numerical simulations, the non-linear dynamic behaviour of the bridge pier under turbulent two-phase flow or

taking flows as frequency excitations is studied. This leads to the evaluation of non-linear dynamic responses through amplitude responses, time domain response diagrams, and phase plan diagrams. The results show good agreement between the analytical and numerical solutions. Moreover, with the obtained results, we show that the increase in wind velocity has a great impact on the heightening of the amplitude response of the system, unlike the rise in water velocity. Furthermore, we demonstrate that for certain values of fluid velocity and height of water, a bridge pier subjected to two-phase fluid flow is more stable than when it is subjected to one fluid flow. Thus, we come to the conclusion that the inertia effects of water contribute to the stabilization of bridge piers in the case of two-phase turbulent flow excitations in the chosen proportions.

Keywords: Bridge pier, Euler-Bernoulli beam theory, two-phase flow excitation, turbulent fluid flow, amplitude of vibration, non-linear dynamic response, water inertia effects, structural stability.

Particles and Fields / 13

Probing New Physics: The Role of Vector-Like Quarks in Rare B-Decays

Author: Maryam Bibi[1]

[1] *Memorial University of Newfoundland*

Corresponding Author: mbibi@mun.ca

We investigate the impact of Vector-Like Quarks (VLQs) on rare B-decay processes. Our approach involves careful examination of VLQ contributions in light of the most recent lower mass limit set by direct search data at LHC. By employing both symbolic and numerical computations, we compare our theoretical produce predictions in agreement with the latest Belle-II results, covering more than 3 sigma deviation from SM expectations. This study aims to shed light on a possible new physics beyond the Standard Model scenario and offer valuable insights for future experimental searches.

Quantum Information / 14

Survey of all additive quantum codes for small systems via graphs

Authors: David L. Feder[1]; Mohsen Mehrani[1]

[1] *University of Calgary*

Corresponding Authors: dfeder@ucalgary.ca, mohsen.mehrani@ucalgary.ca

Scalable, fault-tolerant quantum computing depends on the development of efficient quantum error correction codes. While many good quantum low-density parity-check (qLDPC) codes have been introduced, there is still potential to discover better ones, particularly for small numbers of qubits relevant to the current era of noisy intermediate-scale quantum devices. This research systematically searches for efficient and useful codes by exhaustively analyzing all possible additive codes for small numbers of physical qubits n through a graph representation. Specifically, we examine all non-isomorphic connected simple graphs for $n \leq 10$, and likewise all bipartite graphs for $n \leq 14$ corresponding to CSS codes. Our findings include codes that saturate quantum coding bounds, are competitive with topological codes requiring much larger values of n, are suitable for architectures with local connectivity, and which provide insights into the graph patterns of families corresponding to good codes for larger qubit systems. This work helps to lay the foundation for a systematic code design framework for large-scale quantum systems.

Particles and Fields / 15

Modelling electroweak processes in light nuclei: Nuclear Fermi decays and V_{ud}

Author: Michael Gennari[None]

Co-authors: Chien Yeah Seng [1]; Mehdi Drissi [2]; Misha Gorshteyn [3]; Petr Navratil

[1] *University of Washington*

[2] *TRIUMF*

[3] *Mainz University*

Corresponding Authors: mgennari@triumf.ca, mdrissi@triumf.ca, cyseng@uw.edu, gorshtey@uni-mainz.de, navratil@triumf.ca

Currently, the most precise extraction of the up-down quark mixing element V_{ud} of the Cabibbo-Kobayashi-Maskawa (CKM) matrix comes from a handful of ft-value measurements for nuclear Fermi decays in light- and medium-mass nuclei. However, a complete extraction of V_{ud} from hadronic decays requires challenging theory determinations of hadronic-structure-dependent electroweak radiative corrections (EWRC) to said decays. In fact, a novel evaluation of the free-hadron part of the dominant correction to nuclear Fermi decays, i.e., the free-hadron γW-box diagram, has led to tension with the Standard Model expectation of CKM unitarity. Moreover, to reach the current precision goals for the CKM unitarity test via extraction of V_{ud} from nuclear Fermi decays, a consistent treatment of the hadronic-structure-dependent EWRCs in the nuclear medium is critical. Confirmation of this tension by way of increasingly precise nuclear theory and experiment would point towards a deficiency in the Standard Model (SM) weak sector.

Ultimately, this amounts to requiring a modern evaluation of the nuclear γW-box diagram utilizing the ever-advancing set of tools available in nuclear many-body theory. Targeting an evaluation of the γW-box diagram for the ^{10}C $\rightarrow$ ^{10}B and ^{14}O $\rightarrow$ ^{14}N Fermi transitions, we apply the no-core shell model (NCSM). The NCSM is a non-relativistic quantum many-body approach for modelling the low-lying bound states of light nuclei starting solely from inter-nucleonic interactions. Augmented by the Lanczos strengths method, the NCSM can be further utilized to target features of the entire many-body spectrum, a capability without which calculations of this kind would not be possible. The approach detailed represents one of the first utilized to compute these corrections in ab initio nuclear theory.

Mathematical Physics / 16

Stability of PPT in equilibrium states

Author: Marco Merkli[None]

Co-author: Mitch Zagrodnik

Corresponding Authors: mzagrodnik@mun.ca, merkli@mun.ca

We use simple spectral perturbation theory to show that the positive partial transpose property is stable under bounded perturbations of the Hamiltonian, for equilibrium states in infinite dimensions. The result holds provided the temperature is high enough, or equivalently, provided the perturbation is small enough.

Particles and Fields / 18

Higher Order Leptonic Corrections using Covariant Approach

Author: Mahumm Ghaffar[1]

[1] *Memorial University of Newfoundland*

Corresponding Author: mghaffar@mun.ca

In order to search for physics beyond the Standard Model at the precision frontier, it is sometimes essential to account for higher-order radiative corrections. We perform complete and detailed calculations of electroweak radiative corrections to parity-violating lepton scattering with a distinguishable target (electron-proton, muon-proton) up to Next-to-Next-to-Leading Order (NNLO) level using a covariant approach. In the covariant approach, we apply a unitary cut to the Feynman diagrams and separate them into leptonic and hadronic currents which after contraction gives a total amplitude squared.
Our numerical results are presented at energies relevant for a variety of existing and proposed experimental programs such as QWEAK, P2, MOLLER (background studies), MUSE, and EIC working at the precision frontier. Analysis of these results shows that such corrections at the NNLO level are quite significant to consider at the theoretical level with the increasing precision of future experimental programs at low-energy scales.

Strings and Quantum Gravity / 20

Quantum Cryptography, Tensor Networks, and the Python's Lunch

Author: Chris Waddell[1]

Co-authors: Alex May [1]; Michelle Xu [2]; Sabrina Pasterski [1]

[1] *Perimeter Institute*

[2] *Stanford University*

Corresponding Author: cwaddell@perimeterinstitute.ca

In the AdS/CFT correspondence, a subregion of a conformal field theory (CFT) allows for the recovery of a corresponding subregion of the bulk gravity theory known as its *entanglement wedge*. In some cases, an entanglement wedge contains a locally but not globally minimal surface homologous to the CFT subregion, in which case it is said to contain a *python's lunch*. It has been proposed that python's lunch geometries should be modelled by tensor networks that feature projective operations where the wedge narrows. This model leads to the *python's lunch (PL) conjecture*, which asserts that reconstructing information from past the locally minimal surface is computationally difficult.

In this work, we use cryptographic tools related to a primitive known as the *Conditional Disclosure of Secrets (CDS)* to develop consequences of the projective tensor network model that can be checked directly in AdS/CFT. We argue from the tensor network picture that the mutual information between appropriate CFT subregions is lower bounded linearly by an area difference associated with the geometry of the lunch. Recalling that the mutual information is also computed by bulk extremal surfaces, this gives a verifiable geometrical consequence of the tensor network model. We prove weakened versions of this geometrical statement in asymptotically AdS_{2+1} spacetimes satisfying the null energy condition, and confirm it in some example geometries, supporting the tensor network model and by proxy the PL conjecture.

Condensed Matter Theory / 21

Exploring Collapsed Single-Walled Carbon Nanotubes as Quasi-1D Electronic Systems

Author: Zachary Ireland[1]

[1] *University of Toronto*

Corresponding Author: zacharyigalloway@gmail.com

The collapse of large-diameter, chiral, single-walled carbon nanotubes (SWCNTs) can form bilayer-like ribbons, characterized by quasi-one-dimensional (1D) moiré superlattices and exotic electronic behavior. Using analytical treatments of diameter, chirality, and moiré twist angles, we demonstrate that the moiré wavelength approximates the width of the collapsed SWCNT, producing quasi-1D moiré potentials along its longitudinal axis when the chiral indices are fixed at (n, m=1). This geometry departs from standard two-dimensional twisted bilayer systems by confining the moiré pattern to one dimension. Changes in band structure upon collapse are explored via tight-binding Hamiltonians and Bloch wavefunctions, substantiating that numerical or iterative methods are required for precise predictions. However, by projecting the low-energy Dirac Hamiltonian near the graphene K-point onto the tube's longitudinal axis, we obtain a tractable quasi-1D Hamiltonian that yields approximate insight into the emergent bands when truncated and diagonalized. This projection is akin to slicing a 2D (planar) twisted bilayer graphene sheet into a strip only one moiré unit wide, yielding a quasi-1D ribbon. Toy model calculations employing this slicing approach were carried out to validate the method, successfully reproducing the band structures anticipated for monolayer nanoribbons. To realize these systems experimentally, we highlight spray pyrolysis for producing SWCNTs and employ Density Gradient Ultracentrifugation (DGU) with ssDNA wrapping and Anion-Exchange Chromatography (AEC) to sort tubes by diameter and chirality. Resonance Raman spectroscopy then verifies the sorting by matching each tube's radial breathing mode and optical transition energies to its targeted (n, m) indices. This comprehensive framework provides a direct pathway for synthesizing and investigating collapsed SWCNTs as a platform for strong electronic correlations in 1D moiré lattices.

Nuclear Physics / 23

Ab initio calculations of nuclear parity-violating moments and nuclear structure corrections for tests of fundamental symmetries

Author: Petr Navratil[None]

Co-authors: Mehdi Drissi [1]; Michael Gennari ; Stephan Foster [2]

[1] *TRIUMF*

[2] *McMaster University*

Corresponding Authors: navratil@triumf.ca, fostes18@mcmaster.ca, mdrissi@triumf.ca, mgennari@triumf.ca

First principles, or ab initio, nuclear theory describes atomic nuclei as systems of nucleons interacting by QCD-based chiral effective field theory (EFT) nucleon-nucleon and three-nucleon forces. In combination with chiral EFT electroweak currents, ab initio nuclear calculations can provide model-independent results with quantifiable uncertainties relevant for precision electroweak physics.
We will discuss large-scale calculations performed within the ab initio no-core shell model (NCSM) [1] for observables requiring a computation of the nuclear Green's function that we construct by applying the Lanczos strength method [2]. We will review recent results for parity violating anapole [3], electric dipole [4], and Schiff moments in light atomic nuclei. Also, we will present ongoing calculations of two-photon exchange nuclear structure dependent corrections needed to extract nuclear radii from the measured X-ray spectra of muonic atoms and highlight the effort to compute nuclear structure corrections for the extraction of the Vud matrix element from the superallowed Fermi transition measurements [5]. Finally, we will highlight recent calculations of the nuclear electric dipole polarizability of the 12C ground state and the first excited 2+ state, the latter needed to determine the 2+ electric quadrupole moment from Coulomb excitation experiments.
Supported by the NSERC Grant No. SAPIN-2022-00019. TRIUMF receives federal funding via a contribution agreement with the National Research Council of Canada. Computing support came from an INCITE Award on the Summit and Frontier supercomputers of the Oak Ridge Leadership Computing Facility (OLCF) at ORNL, from the Digital Research Alliance of Canada, and from the LLNL institutional Computing Grand Challenge Program.
[1] B. R. Barrett, P. Navratil, J. P. Vary, Progress in Particle and Nuclear Physics 69, 131 (2013). [2] R.

Haydock, J. Phys. A 7, 2120 (1974). [3] Yongliang Hao, Petr Navratil, Eric B. Norrgard, Miroslav Ilias, Ephraim Eliav, Rob G. E. Timmermans, Victor V. Flambaum, and Anastasia Borschevsky, "Nuclear spin-dependent parity-violating effects in light polyatomic molecules,"Phys. Rev. A 102, 052828 (2020). [4] Paul Froese and Petr Navratil, "Ab initio calculations of electric dipole moments of light nuclei,"Phys. Rev. C 104, 025502 (2021). [5] Michael Gennari, Mehdi Drissi, Mikhail Gorchtein, Petr Navratil, and Chien-Yeah Seng, "Ab initio calculation of the nuclear-structure-dependent radiative corrections in 10C superallowed transition,"Phys. Rev. Lett. 134, 012501 (2025).

Nuclear Physics / 24

Introducing foundational theory topics in a theoretical physics laboratory course

Author: Mark Robert Baker[1]

[1] *Western University*

Corresponding Author: mbaker66@uwo.ca

Upper year theoretical physics courses are conventionally delivered in a strict didactic form, where the instructor delivers 3 independent hour-long lectures per week. In the didactic method, students are left to work through the related highly complex and lengthy derivations independently. The degree to which these are assessed varies as they are difficult to incorporate into standard didactic course assessments. To help address this gap we developed a "Theoretical Physics Laboratory"course which we were later able to offer and complete a corresponding study on. In this course we use instructional approaches based on scaffolded active learning during a single lengthy session, once per week. The single meeting is designed similar to laboratory based learning for experimental courses, and is modeled after popular "escape-rooms", where students must work together to finish a flexible list of tasks related to theory topics in different branches of physics. Results from the study provide some evidence for including a course of this style in upper year physics course offerings. In our presentation we will discuss items such as the course design, study and results, instructional methodologies, and the PAALS "Physics and Astronomy Active Learning Space"developed by our department. We will also provide some sample teaching materials and discuss the basic function of the weekly session of the course.

Relativity, Gravitation and Cosmology / 25

Constructing gravitational instantons

Author: Hari Kunduri[1]

[1] *McMaster University, Mathematics and Physics*

Corresponding Author: kundurih@mcmaster.ca

Gavitational instantons are complete, Ricci-flat Riemannian manifolds (M,g) characterized by their asymptotic behaviour. We will cosnider asymptotically locally Euclidean (ALE) (a quotient of Euclidean space) with quartic volume growth, and asymptotically locally flat (ALF) spaces with cubic volume growth (e.g. a circle bundle over R^3). Explicit examples can be constructed from known black hole metrics while others have no Lorentzian analogue. We will show that when reduced under toric symmetry, the Ricci flat equations are equivalent to a harmonic map. This can be used to construct a wide class of ALE and ALF examples.

Nuclear Physics / 26

The Equation of State and relic neutrinos from neutron star mergers

Author: Liliana Caballero Suarez[None]

Corresponding Author: ocaballe@uoguelph.ca

As standalone detections or in the context of multi-messenger signals, neutrinos offer opportunities to understand our universe in unprecedented ways. Their weakly interacting nature provides information about, among others, binary neutron star mergers. Interpreting neutrino observations from compact objects relies on models of neutrino emission and the still not fully understood nuclear matter Equation of State (EOS). While much can be learned from the neutrinos emitted by a single merger, the rarity of these events poses challenges for their detection. Unlike single events, relic neutrinos emitted since the first mergers occurred in the universe, provide a continuous background flux that offers an additional avenue for the study of matter under strong gravity. In this talk, I shall discuss the diffuse neutrino background from neutron star mergers, and the prospects of learning about the equation of state of nuclear matter from its possible detection.

Relativity, Gravitation and Cosmology / **27**

Solar Flares From Black Holes: Electromagnetic Signals From Merging Supermassive Black Holes

Author: Sean Ressler[1]

Co-authors: Bart Ripperda [2]; Elias Most [3]; Huan Yang ; Luciano Combi [4]; Xinyu Li [5]

[1] *Canadian Institute for Theoretical Astrophysics*

[2] *Canadian Institute for Theoretical Astrophysics/University of Toronto*

[3] *California Institute of Technology*

[4] *Perimeter Institute/University of Guelph*

[5] *Tsinghua University*

Corresponding Authors: hyang@perimeterinstitute.ca, lcombi@perimeterinstitute.ca, seanmressler@gmail.com

When two galaxies collide, the supermassive black holes located at their centers can form a binary pair. These extreme gravitational situation causes ripples in spacetime (called gravitational waves) that carry away significant energy and angular momentum so that the two black holes themselves eventually collide. During the in-spiral phase, the gravitational waves are measurable by current and future space-based detectors. At the same time, the abundance of gas provided by the surrounding galaxies can heat up to extreme temperatures and simultaneously emit detectable electromagnetic radiation. Combining these observations will allow us to study the strong-field limit of general relativity in an unprecedented manner and also provide key insights into how galaxies grow and evolve over time. General relativistic fluid dynamic simulations allow us to more precisely predict how these systems would appear. In this talk I will summarize some recent simulations that reveal solar-flare-like emission that would provide a unique signature of otherwise hidden binary pairs in galaxy center.

Nuclear Physics / **28**

Mixed-spin pairing in deformed heavy nuclei

Author: Alex Gezerlis[1]

[1] *University of Guelph*

Corresponding Author: gezerlis@uoguelph.ca

Traditional pairing in nuclear systems is of the identical-particle kind (i.e., neutron-neutron or proton-proton). This is counter-intuitive, given that the neutron-proton interaction is stronger. In earlier work, we had hypothesized that such neutron-proton pairing may appear in heavy nuclei. Such studies had assumed spherical symmetry, which is known to be an inappropriate assumption in this region of the nuclear chart. In recent work we extended our formalism and carried out mean-field pairing studies in the presence of deformation. We found that neutron-proton pairing survives and should be experimentally accessible. Time permitting, I may also discuss related work using ab initio many-body techniques.

Mathematical Physics / 29

Wightman Axioms for Hopf-Frobenius Modules

Author: Matt Alexander[1]

[1] *University of Regina*

Corresponding Author: alexand2tice@gmail.com

Frobenius algebras and Hopf algebras generalize algebras of functions and Lie groups/Lie algebras, respectively. Appropriate constructions involving these two types of algebras link together concepts from functional analysis with those from Lie theory. As quantum field theories often involve a mixture of analytic and algebraic structures (for instance, performing analysis on operator-valued distributions), Hopf-Frobenius constructions may play an important role in understanding the underlying structure of these theories.

In this talk we will introduce the notion of a Hopf-Frobenius module, and show how the Wightman axioms can be viewed as natural axioms on a collection of such modules.

Mathematical Physics / 30

Looking at bulk points in general geometries

Author: Joydeep Chakravarty[1]

[1] *McGill University*

Corresponding Author: joydeep.chakravarty@mail.mcgill.ca

The holographic correspondence predicts that certain strongly coupled quantum systems describe an emergent, higher-dimensional bulk spacetime in which excitations enjoy local dynamics. We consider a general holographic state dual to an asymptotically AdS bulk spacetime, and study boundary correlation functions of local fields integrated against wavepackets. We derive a factorization formula showing that when the wavepackets suitably meet at a common bulk point, the boundary correlators develop sharp features controlled by flat-space-like bulk scattering processes. These features extend along boundary hyperboloids whose shape naturally reveals the bulk geometry. We discuss different choices of operator ordering, which lead to inclusive and out-of-time-ordered amplitudes, as well as fields of various spins and masses.

Quantum Information / 31

A Type Theory for Higher-Order Quantum Maps

Author: Carlo Maria Scandolo[1]

[1] *University of Calgary*

Corresponding Author: carlomaria.scandolo@ucalgary.ca

Quantum maps are central objects that allow the manipulation of quantum states and resources. However, not all maps are created equal, and some may be more valuable than others in performing certain resource conversions. For this reason, transforming a quantum map into another, possibly more desirable one, becomes a relevant and crucial task in quantum information processing. Such a transformation is achieved by the so-called quantum supermaps. However, there is no reason to stop at this level, and one could conceive super-supermaps that transform quantum supermaps into quantum supermaps, and so on. This construction leads to an infinite ladder of higher-order quantum maps. This talk will present an attempt to build a systematic and unified formalism to describe *all* such higher-order quantum maps at *any* level of their hierarchy, with the ultimate goal of studying their information-theoretic capabilities and physical implications on the issue of quantum causality.

Quantum Information / 32

Conditions to circumvent Eastin-Knill restrictions

Author: Pragati Gupta[1]

Co-author: Barry Sanders

[1] *University of Calgary*

Corresponding Authors: pragati.gupta@ucalgary.ca, sandersb@ucalgary.ca

A long-standing challenge in quantum error correction is the infeasibility of universal transversal gates, as shown by the Eastin- Knill theorem. We show that the Eastin-Knill no-go result is a special case that does not hold for a general error model and obtain a necessary and sufficient condition for a quantum error-correcting code to have universal transversal gates. Introducing a Lie algebraïc approach, we completely classify transversally implementable gate sets for fault-tolerant quantum computing, quantum metrology, and codes for the AdS/CFT correspondence, only depending on the errors on a quantum system. We present a code construction with universal transversal gates that changes the logical error probability from a lower bound to an upper bound, and enables exact correction of both local and correlated errors that affect many experimental platforms.

Mathematical Physics / 33

Spectrum of the Laplacian on the Page Metric

Author: Kam To Billy Sievers[1]

[1] *McMaster University*

Corresponding Author: sieversktb@mcmaster.ca

Computing the spectrum of the Laplace operator on a compact Riemannian manifold is a classic problem in mathematical physics. For this presentation, we consider the four-dimensional Einstein

metric on the non-trivial S^2-bundle over S^2 discovered by Page. A pseudospectral method is used to approximate the spectrum of the scalar Laplacian. We show our numerical results match well with recent estimates using geometric analysis techniques. We also analyze the spectrum of the Lichnerowicz Laplacian, which acts on symmetric two-tensors. This operator determines the stability of the Page metric under deformations. We show that there is a single negative eigenvalue, indicating instability, confirming a previous result of Young. A perturbative analysis is also done for the scalar case which matches the numerical results.

Relativity, Gravitation and Cosmology / 34

Big Bang Nucleosynthesis in the Era of Precision Cosmology

Author: Tsung-Han Yeh[1]

[1] *TRIUMF*

Corresponding Author: thyeh@triumf.ca

Big Bang Nucleosynthesis (BBN) describes the very first nucleosynthesis in the universe. The nuclear network of BBN produces the lightest elements and explains their cosmic abundances. With precision abundance observations, BBN can probe the physics of the early universe and place limits on key cosmological parameters. These key parameters also leave their imprint in the cosmic microwave background (CMB), the afterglow from the baby universe. A recent successful space mission called Planck provides independent precision determinations of their values. The agreement between BBN and the CMB results stands for the success of standard cosmology. Relevant recent work at the precision frontier of BBN will be discussed. In addition, the combined BBN+CMB limits could place important constraints on new physics, a complementary indirect approach to laboratory search. We will close this talk with some BSM scenarios to exemplify the use of BBN in the quest for signs of exotic physics.

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Noncommutative formulation of classical mechanics

Author: Mustafa Amin[1]

Co-author: Mark Walton

[1] *University of Lethbridge*

Corresponding Authors: m.amin@uleth.ca, walton@uleth.ca

Classical mechanics can be cast in a framework that represents observables as operators and states as vectors in some Hilbert space, as shown by Koopman and von Neumann. In such a formulation, noncommuting operators naturally arise and the question of their physical interpretation is relevant for understanding both classical and quantum mechanics. We describe a general map from ordinary phase-space variables to operators for classical theories, and discuss its usefulness and physical relevance.

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Multipartite Superposition of Spacetime from an Operational Perspective

Author: Everett Patterson[1]

[1] *University of Waterloo*

Corresponding Author: ea2patte@uwaterloo.ca

It is widely anticipated that a quantized theory of gravity will admit quantum spacetime configurations that are described by a superposition of semiclassical spacetimes. However, in the absence of such a complete theory of quantum gravity, can we learn anything about how such states might behave?
In this talk, I will present a recent operational approach to this problem using a first-quantized two-level quantum detector coupled to a quantum-controlled superposition of spacetimes. While this framework has been used to describe bipartite superpositions of black hole masses and accelerated detectors, I will here expand the framework to consider multipartite superpositions and comment on the connection between these set-ups and entanglement harvesting protocols.

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Welcome

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Opening Remarks

Corresponding Author: zisis.papandreou@uregina.ca

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Opening Remarks

Corresponding Author: zisis.papandreou@uregina.ca