
Mathematical Physics
Physique mathématique

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MATTHEW ALEXANDER, (Formerly) University of Regina
Hopf-Frobenius Gauge Theories

Hopf algebras and Frobenius algebras are two structures that have found important roles in formulating quantum field theory: Hopf algebras in the guise of quantum groups, and Frobenius algebras in the realm of topological quantum field theories. In this talk, we present a compatibility structure between these two algebras, which we call *Hopf-Frobenius modules*, and show how these modules generalize the geometric, analytic, and algebraic structures that appear in field theory, allowing us to formulate a notion of gauge theory in this setting.

SETH ASANTE, University of New Brunswick

Deferred Cyclotomic Representations: Exact Algebraic Evaluation of Quantum Group Invariants and q -Hypergeometric Series

The computation of topological invariants for 3-manifolds, such as the Turaev-Viro state sums, relies heavily on the representation theory of the quantum group $U_q(\mathfrak{sl}_2)$. The fundamental building blocks of these invariants (such as the quantum $6j$ -symbols) are expressed as complex q -hypergeometric series. Evaluating these rational functions poses severe challenges. Standard evaluations rely on dense polynomial or rational formulations, which trigger expression swell in exact symbolic algebra and severe catastrophic cancellation in finite-precision arithmetic.

In this talk, we introduce the Deferred Cyclotomic Representation (DCR) of the q -hypergeometric series, an algebraic framework that resolves these computational bottlenecks. By mapping the multiplicative structure of q -factorials onto a free abelian group generated by irreducible cyclotomic polynomials, the DCR framework translates algebraic multiplication and division into exact sparse integer vector additions. This isolates the combinatorial skeleton of the series from the target evaluation field. We shall demonstrate how DCR enables the extraction of common polynomial divisors, intrinsically resolves root-of-unity poles, and allows the evaluation of generic tensor category identities in exact cyclotomic fields. `QRecoupling.jl` open-source package is developed for further research and applications.

CONNOR BEHAN, Perimeter Institute

Supercharge cohomology in holographic theories

To leverage the full power of holographic duality, one must be able to interpolate between weak and strong coupling on the field theory side. This can be done for the superconformal index which is coupling independent but still sensitive to the distinction between multi-graviton states and black holes. I will discuss a natural refinement of this which comes from viewing supersymmetric states through the lens of cohomology. Although this space receives corrections in perturbation theory, these appear in a rather controlled way. This viewpoint makes it easier to search the low-lying Hilbert space and it also makes some relations between different theories more transparent. I will give thoughts on how supercharge cohomologies can serve as fundamental data of supersymmetric gauge theories with their own universality classes.

ADRIAN CHITAN, Western University

Stratification and Quantization of Chern-Simons Phase Space: Towards Witten's Asymptotic Conjecture

In three-dimensional topological quantum field theory, the Witten-Reshetikhin-Turaev (WRT) invariants are famously formulated via the path integral of Chern-Simons gauge theory. The rigorous geometric quantization of the underlying classical phase space—the moduli space of flat $SU(2)$ connections on a Riemann surface—provides a powerful mathematical framework

for understanding these physical invariants. However, traditional geometric approaches, such as those relying on the Jeffrey-Weitsman-Witten (JWW) invariants, have historically faced limitations due to the presence of singular strata corresponding to reducible connections.

This talk presents a stratified quantization recipe for the half density, or half-form bundle, over the moduli space which incorporates these singular strata independently into the defining integral. By isolating the treatment of the singularities we more closely harmonize the geometrically derived invariants with the expected WRT invariants from QFT.

SERAPHIM JAROV, Perimeter Institute
Novel integrable PDEs from twistor theory

Twistor theory beautifully captures the solutions of 4d non-linear PDEs within complex geometric data. I will explain this correspondence and introduce novel deformations of classic PDEs that admit interesting twistorial descriptions. Time permitting, I will also touch on exciting connections to vertex operator algebras, topological string theory, and scattering amplitudes.

PETER MARZLIN, St. Francis Xavier University
Locality and the phase space representation of quantum fields

The Hegerfeldt theorem asserts that any localized state of a relativistic particle would become delocalized in an arbitrarily short time. We derive a phase space representation of non-relativistic and relativistic quantum fields that circumvents this problem by using a set of localized wave packets that are neither particles nor anti-particles. The dynamical equation of the probability amplitude takes the form of a classical Vlasov equation with quantum corrections. We discuss applications of the method, including Schwinger and Unruh effect.

WENJUN NIU, Perimeter Institute for Theoretical Physics
Line operators and BPS algebras

BPS algebras are important invariants of 4d $N=2$ SCFTs. Recently, Gaiotto-Grygoryev-Li proposed that the category of 1/2-BPS line operators of the theory is controlled by the category of bimodules of the corresponding BPS algebra. However, their proposal was incomplete as the category of bimodules lack the structure of a spectral braiding. In this talk, I will explain that by considering a more refined category of bimodules, one can obtain a spectral braiding between objects. We propose this refined category to be the category of 1/2-BPS line operators. We give credence to this proposal by showing that when the BPS algebra is associated to a type A quiver, the corresponding category is equivalent to representations of type-A Yangians. This is based on joint work in preparation with S. DeHority and A. Latyntsev.

ADRIAN LOPEZ RAVEN, Perimeter Institute
Categorical 't Hooft Expansion and Chiral Algebras

It is over 50 years since 't Hooft noted that Quantum Field Theories with matrix-valued fields furnish a String Theory expansion as the rank of the matrices goes to infinity. Several examples of this correspondence are known and go by the name of Holography, though no general recipe to construct the dual String Theory is known.

In this work, we derive B-model String Theory dual data for a wide family of matrix-valued chiral algebras. Amongst the dual String Theory backgrounds, one finds novel non-commutative geometries. Using techniques from Homological Algebra, we extract universal properties of the conjectural worldsheet theories dual to these chiral algebras, in the form of A_∞ categories and modules. We believe some of the techniques developed in this work may find use in broader examples of Holography.

RUBEN SANDAPEN, Acadia University
Conformal inversion in the internal light-front dynamics of a pion

In light-front Quantum Chromodynamics (QCD), there is a natural separation between longitudinal and transverse dynamics. Here, we focus on the pion where we find that the equations of motion governing transverse and longitudinal dynamics map onto the infrared and ultraviolet limits of the equation of motion for a scalar field in 5-dimensional anti de Sitter spacetime (AdS) deformed by a quadratic dilaton. While conformal symmetry is explicitly broken on the AdS side for transverse dynamics, it is explicitly broken on the QCD side for longitudinal dynamics.

ROBERT VAN DEN HOOGEN, St. Francis Xavier University
Using gauge covariant Lie derivatives to impose symmetries

A procedure to determine the initial ansatz for the co-frame and spin connection characterizing a Riemann-Cartan geometry respecting a given group of continuous symmetries is illustrated by employing a gauge covariant Lie derivative to the metric, co-frame and spin connection. The procedure will be applied to a simple non-trivial geometry in teleparallel gravity.

CHRIS WADDELL, Perimeter Institute
On sufficient conditions for holographic scattering

In AdS/CFT, scattering in the bulk can be mediated by entanglement on the boundary. The connected wedge theorem (CWT) of May, Penington, and Sorce is a concrete example where bulk scattering implies correlation between certain boundary regions. However the converse does not hold. We investigate a recent proposal of Leutheusser and Liu for a generalization of the CWT with converse. We prove the forward direction: having pairs of CFT "input" (and likewise "output") regions in a phase with connected entanglement wedge implies that a particular bulk subregion (the intersection of "input" and "output" entanglement wedges) is non-empty. We then establish a modified version of the proposal which has a converse, and identify counter-examples to the stronger conjecture.