

# Geometry of Quantum Fields and Strings

Conference on the Mathematics of Gauge Theory and String Theory

University of Auckland

10-12 January 2020

## Abstracts

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**Speaker:** Mina Aganagic

**Title:** Knot categorification from geometry and mirror symmetry, via string theory

**Abstract:** I will describe how two geometric approaches to categorification of quantum knots emerge from string theory. One of these approaches had been discovered by mathematicians earlier. It is based on derived categories of coherent sheaves on resolutions of slices in affine Grassmannians. The second approach is new. It is related to the first by two dimensional (equivariant) mirror symmetry. Unlike previous approaches based on symplectic geometry, it produces a bi-graded homology theory. I will illustrate how this new theory categorifies the Jones polynomial. Time permitting, I will explain the relation to another string theory based approach, due to Witten.

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**Speaker:** Stavros Garoufalidis

**Title:** Knots, their  $q$ -series and their asymptotic series

**Abstract:** Recent work of Gukov et al aims to compute the supersymmetric index of a 3-manifold, an analytic function in the open unit disk, and its asymptotic series, a factorially divergent series. The functions are parametrized by suitable flat connections as well as by roots of unity. In joint work with Don Zagier we propose definitions of these functions for the case of some knot complements and illustrate their structure.

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**Speaker:** Michael Freedman

**Title:** Some strange thoughts on the interface between math and physics

**Abstract:** I will describe some thoughts on:

1. How many body physics could be an illusion, and that the universe is “really” a single particle in a “flat band”,
2. That curvature as seen in EM, standard model physics, and gravity, might merely be an effective description of suitable flat connections over a topologically wild space-time. And, time permitting,
3. Speculation on how physics might provide a foundation for mathematics rather than the other way around.

Warning: even by my standards these ideas will be strange.

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**Speaker:** Rafe Mazzeo

**Title:** Parabolic Hitchin systems, ALG spaces and  $K3$  metrics

**Abstract:** I will discuss recent results about Hitchin moduli spaces and their natural  $L^2$  metrics, and a resolution of a significant part of a conjecture by Gaiotto-Moore-Neitzke. This is sharp in some special four-dimensional cases, and leads to an identification of the moduli space of ALG gravitational instantons. These ALG spaces, in turn, are building blocks for a particularly simple and asymptotically sharp description of a certain degenerating family of  $K3$  metrics.

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**Speaker:** Clifford Taubes

**Title:**  $\mathbb{Z}_2$  harmonic 1-forms and the Kapustin-Witten invariants

**Abstract:**  $\mathbb{Z}_2$  harmonic 1-forms are closed and coclosed 1-forms with values in a real line bundle that is defined on the complement of a codimension 2 subvariety of a Riemannian manifold with their norms being zero on this same subvariety. These objects are now known to appear (in dimensions 2-4) in diverse contexts involving  $SL(2, \mathbb{C})$  gauge theories. I hope to tell you a story about these objects and the role that they might be playing with regards to the differential topology of low dimensional manifolds. For those interested in analysis: There is a lot of that to be done also!

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**Speaker:** Mathai Varghese

**Title:** T-duality, loop space and Witten gerbe modules

**Abstract:** I will talk about my recent joint work with Fei Han, [arXiv:2001.00322], where we extend what is now known as topological T-duality isomorphism on T-dual circle bundles with background flux, to the free (small) loop space of these T-dual circle bundles.

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**Speaker:** Edward Witten (Talk I)

**Title:** Knot Invariants From Gauge Theory In Three, Four or Five Dimensions

**Abstract:** I will recall how the Jones polynomial of a knot can be described by gauge theory in three dimensions, and then I will explain how a lift of this story to four dimensions leads to a “dual” picture of the Jones polynomial in terms of counting of the solutions of certain equations in four dimensions. A further lift to five dimensions gives a candidate gauge theory description of Khovanov homology.

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**Speaker:** Edward Witten (Talk II)

**Title:** Searching for New Invariants of Smooth Four-Manifolds

**Abstract:** I will describe some attempts to use gauge theory to define new invariants of smooth four-manifolds.

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