Geometric Unification via Six-Dimensional Physics
May 24-29, 2015

MEALS

*Breakfast (Buffet): 7:00–9:30 am, Sally Borden Building, Monday–Friday
*Lunch (Buffet): 11:30 am–1:30 pm, Sally Borden Building, Monday–Friday
*Dinner (Buffet): 5:30–7:30 pm, Sally Borden Building, Sunday–Thursday
Coffee Breaks: As per daily schedule, in the foyer of the TransCanada Pipeline Pavilion (TCPL)
***Please remember to scan your meal card at the host/hostess station in the dining room for each meal.**

MEETING ROOMS

All lectures will be held in the lecture theater in the TransCanada Pipelines Pavilion (TCPL). An LCD projector, a laptop, a document camera, and blackboards are available for presentations.

SCHEDULE

Sunday

16:00	Check-in begins (Front Desk - Professional Development Centre - open 24 hours)
17:30–19:30	Buffet Dinner, Sally Borden Building
20:00	Informal gathering in 2nd floor lounge, Corbett Hall (if desired) Beverages and a small assortment of snacks are available on a cash honor system.

Monday

7:00–8:45	Breakfast
8:45–9:00	Introduction and Welcome by BIRS Station Manager, TCPL
9:00–10:15	**Gaiotto**
10:15–10:45	Coffee Break, TCPL
10:45–12:00	**Neitzke**
12:00–13:00	Lunch
13:00–14:00	Guided Tour of The Banff Centre; meet in the 2nd floor lounge, Corbett Hall
14:00	Group Photo; meet in foyer of TCPL (photograph will be taken outdoors so a jacket might be required).
14:05–15:05	**Beem**
15:05–15:30	Coffee Break, TCPL
15:30–16:30	**Costello**
16:45–17:45	**Discussion session**
17:45–19:30	Dinner

Tuesday

7:00–9:00	Breakfast
9:00–10:15	**Gaiotto**
10:15–10:45	Coffee Break, TCPL
10:45–12:00	**Teschner**
12:00–13:30	Lunch
14:00–15:00	**Dimofte**
15:00–15:30	Coffee Break, TCPL
15:30–16:30	**Nakajima**
16:45–17:45	**Cordova**
17:45–19:30	Dinner

Wednesday

7:00–9:00	Breakfast
	Free morning
12:00–13:30	Lunch
15:00–16:15	**Gaiotto**
16:45–18:00	**Ben-Zvi**
18:00–19:30	Dinner
19:30–20:30	**Discussion session**

Thursday

7:00–9:00	Breakfast
9:00–10:15	**Teschner**
10:15–10:45	Coffee Break, TCPL
10:45–12:00	**Freed**
12:00–13:30	Lunch
14:00–15:00	**Nadler**
15:00–15:30	Coffee Break, TCPL
15:30–16:30	**Goncharov**
16:45–17:45	**Discussion session**
17:30–19:30	Dinner

Friday

7:00–9:00	Breakfast
9:00–10:15	**Gukov**
10:15–10:45	Coffee Break, TCPL
10:45–12:00	**Ben-Zvi**
11:30–13:30	Lunch
Checkout by 12 noon.	

** 5-day workshop participants are welcome to use BIRS facilities (BIRS Coffee Lounge, TCPL and Reading Room) until 3 pm on Friday, although participants are still required to checkout of the guest rooms by 12 noon. **

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ABSTRACTS

Speaker: **Chris Beem** (IAS)
Title: *Comments on the operator algebra of the (2,0) theory*
Abstract: The algebra of local operators in the (2,0) theory is strongly constrained by superconformal invariance and associativity of the operator product expansion. I will describe a "twist" of this algebra that produces a structure equivalent to that of a two-dimensional vertex operator algebra (VOA). I will further argue that the VOA obtained in this way from the (2,0) theory of type $\mathfrak{g}$ is the corresponding affine W-algebra. The algebra of local operators associated to a defect operator in the (2,0) theory can be similarly twisted, and the resulting VOA identified as an affine current algebra at the critical level.

Speaker: **David Ben-Zvi** (UT Austin)
Title: *Geometry of extended field theories*
Abstract: I'll explain (following discussions with Nadler, Neitzke and Nevins) some of the geometry that can be formally extracted from the structure of extended field theory. This includes Seiberg-Witten integrable systems and their quantization in the case of 4-dimensional TFTs and aspects of the AGT and geometric Langlands correspondences in the case of theory $\mathfrak{X}$.

Speaker: **Clay Cordova** (Harvard)
Title: *Applications of Superconformal Representation Theory*
Abstract: Local operators in supersymmetric conformal field theory are in representations of the superconformal group. In this talk, I will briefly review this representation theory and apply it to shed light on some basic questions such as: Are there $(N, 0)$ superconformal field theories? Do the (2,0) theories have continuous parameters or global symmetries? Why is the (2,0) theory on a circle described by 5d Super-Yang-Mills? How can we understand the RG flow of the (2,0) theory on its moduli space?

Speaker: **Kevin Costello** (Perimeter)
Title: *Twisted M theory, the Maulik-Okounkov Yangian, and the AdS dual of the Beem-Rastelli twist of the (2,0) theory*
Abstract: I will give a conjectural description of a twist of 11 dimensional supergravity, which I will argue is AdS dual to a twist of the six dimensional (2,0) theory. I will argue that the algebra of operators of the gravity theory is Koszul dual to the Yangian studied by Maulik-Okounkov, which arises as the large N limit of the affine W algebra and which acts on the cohomology of the moduli space of instantons. This is an example of a general framework expressing the AdS/CFT correspondence in terms of Koszul duality for factorization algebras.

Speaker: **Tudor Dimofte** (IAS)
Title: *The Coulomb Branch of 3d $N = 4$ Gauge Theories*
Abstract: The moduli space of a 3d $N = 4$ gauge theory contains at least two branches, typically referred to as Higgs and Coulomb. Both are hyperkahler manifolds with some special properties, but while the Higgs branch has a straightforward classical construction, the Coulomb branch is affected by quantum corrections and has long remained mysterious. I will discuss a physically motivated construction of both the ring of holomorphic functions on the Coulomb branch and its hyperkahler structure. I also hope to touch upon boundary conditions in 3d $N = 4$ gauge theories, and their images on the Higgs and Coulomb branches, which tie 3d $N = 4$ gauge theory to geometric representation theory in mathematics. This project was initially motivated by constructions of knot homology using the 6d (2,0) theory; 3d $N = 4$

theories also arise naturally from compactification of the 6d (2,0) theory on a surface and an additional circle. (Joint work with M. Bullimore, D. Gaiotto, and J. Hilburn.)

Speaker: **Dan Freed** (UT Austin)
Title: *Relative field theories*
Abstract: Just as in geometry we often work over a nontrivial base, so too is there a relative notion of a field theory. After an introduction with some examples, I will describe how Theory $\mathfrak{X}$ can be viewed as a relative field theory.

Speaker: **Davide Gaiotto** (Perimeter)
Title: *Lectures on the six-dimensional (2,0) SCFTs*
Abstract: I will review various aspects of six-dimensional (2,0) SCFTs.

Speaker: **Alexander Goncharov** (Yale)
Title: *Moduli spaces of G-local systems, 3d Calabi-Yau categories, and their DT-transformations*
Abstract: Given a decorated surface S, there is a cluster Poisson variety $P(m, S)$, closely related to the moduli space of m-dimensional flat connections on S with some data on the boundary.
It can be categorified to a 3d CY category $C(m, S)$ with an extra data: an array of "cluster collections of spherical generators". The K_0 of the category $C(m, S)$ with a given cluster collection describes a cluster coordinate system on the space $P(m, S)$.
Kontsevich and Soibelman defined Donaldson-Thomas invariants of a 3d CY category C, and packaged them to a single invariant: a formal power series transformation on the $K_0(C)$, called now the DT-transformation.
In a joint work with Linhui Shen (Northwestern U) we calculate the DT-transformation for the category $C(m, S)$, and prove that it is an element of the cluster modular group of the space $P(m, S)$.

Speaker: **Sergei Gukov** (Caltech)
Title: *Survey into 3d-3d correspondence*
Abstract: Compactification of the 6d fivebrane theory on 3-manifolds is believed to result in a particular class of 3d $N = 2$ theories, whose physical properties contain rich information about geometry and topology of 3-manifolds. In this talk, I will survey the status of this subject, from basic ideas to what in financial markets are called "stress test" examples, which expose limitations, challenges, and open questions that require further development.

Speaker: **David Nadler** (Berkeley)
Title: *Examples of Betti Langlands*
Abstract: I'll report on an ongoing project to understand the Betti version of geometric Langlands, which depends only on the topology of the curve (as appears in physical descriptions of the subject). I'll describe specific instances in low genus where mirror symmetry/S-duality can be established, or should be amenable to current techniques. Various parts represent joint work with David Ben-Zvi and Zhiwei Yun.

Speaker: **Hiraku Nakajima** (Kyoto / RIMS)
Title: *Towards a mathematical definition of Coulomb branches of 3-dimensional N=4 gauge theories*
Abstract: Let M be a quaternionic representation of a compact Lie group G. Physicists study the Coulomb branch of the 3-dimensional gauge theory associated with (G,M), which is a hyper-Kaehler manifold, but have no rigorous mathematical definition. When M is of a form $N + N^*$, we introduce a variant of the affine Grassmannian Steinberg variety, define convolution product on its equivariant Borel-Moore homology group, and show that it is commutative. We propose that it gives a mathematical definition of the coordinate ring of the Coulomb branch. (Joint work by Braverman, Finkelberg and Nakajima)

Speaker: **Andrew Neitzke** (UT Austin)
Title: *An introduction to compactification of the* $(2, 0)$ *theory*

Abstract: I will review the idea of *compactification* of the $(2,0)$ theory (also called "Theory $\mathfrak{X}$"). This procedure yields a rich spectrum of quantum field theories in lower dimensions, which has been the starting point for various developments in supersymmetric quantum field theory over the last few years, with consequences for geometry of various sorts. I will focus on the example of compactification on a Riemann surface C, which yields a class of 4-dimensional quantum field theories known as "class S". The special case $C = T^2$ yields $N = 4$ super Yang-Mills theory, which (through work of Kapustin-Witten) is related to the geometric Langlands program.

Speaker: **Joerg Teschner** (DESY)
Title 1: *Field theories of class S, quantisation of Hitchin's moduli spaces, and conformal field theory*
Abstract 1: The aim of this talk will be to review some aspects of the triangle of existing relations between $N = 2$ supersymmetric gauge theories of class S, Hitchin's moduli spaces (classical and quantised), and conformal field theory. My plan is to address the following two questions: (i) What's the relevance of the (quantised) moduli spaces of flat connections for class S theories ? (ii) What's the relation between the quantum theory of Hitchin's moduli spaces and conformal field theory ?
Title 2: *Surface operators in A_N-theories of class S, and conformal field theory*
Abstract 2: The relations between class S theories and CFT get enriched further in the presence of surface operators. In the case of codimension 4 surface operator one expects relations to the conformal blocks of the W-algebra with extra degenerate fields inserted. The goal in my talk will be to describe simple aspects of the interplay between surface and line operators in gauge theory and CFT. The origin from the six-dimensional (2,0) theory suggests analogies (relations?) to the geometric Langlands correspondence.