

Nankai Symposium on Physics, Geometry and Number Theory 2017

July 31 - August 5, 2017

**Chern Institute of Mathematics
Nankai University, China**

Organizing Committee

Mo-Lin Ge
Chengming Bai
Yang-Hui He
Rak-Kyeong Seong
Yan Xiao

Supported By

Chern Institute of Mathematics, Nankai University, China

Program at a glance

	Monday 31/7	Tuesday 1/8	Wednesday 2/8	Thursday 3/8	Friday 4/8
<i>Chair</i>	<i>He</i>	<i>S. Lee</i>	<i>Ramgoolam</i>	<i>Vidunas</i>	<i>Jejjala</i>
9:30-10:30	REGISTRATION				
10:00-11:00	PHOTO (10:30); Opening Speech (10:50)	K. Lee	Candelas	Ramgoolam	M. Huang
11:00-12:00	Carnahan	J. Park	M. Kim	Gannon	Ovrut
12:00-14:00	LUNCH	LUNCH	LUNCH	LUNCH	LUNCH
<i>Chair</i>	<i>Seong</i>	<i>Dechant</i>		<i>Broomhead</i>	<i>Huang</i>
14:00-15:00	Yokoyama	Tan	FREE AFTERNOON	Feng	Broomhead
15:00-15:30	BREAK	BREAK	sightseeing	BREAK	BREAK
15:30-16:30	Miyamoto	S. Lee	local restaurant	Salerno	Dechant
16:30-17:30	Xiao	W. Yang		Vidunas	Jejjala
18:30	DINNER	DINNER		DINNER	DINNER

Program

31 July, Monday

Lecture Hall 216, Shiing-Shen Building

Chair: Yang-Hui He

9:30-10:30 Registration

10:30 Photo

10:50 Opening Speech

11:00-12:00 Scott Carnahan (Tsukuba University, Japan)

Generalized Monstrous Moonshine

12:00-14:00 Lunch

Chair: Rak-Kyeong Seong

14:00-15:00 Daisuke Yokoyama (Fudan University, China)

Talk Title here

15:00-15:30 Break

15:30-16:30 Masahiko Miyamoto (Tsukuba University, Japan)

Twelfth Night and Super Conformal Algebra of central charge 6

16:30-17:30 Yan Xiao (City, University of London, UK)

A New Dimer System and Quiver Gauge Theory

18:30 Dinner

1 August, Tuesday

Lecture Hall 216, Shiing-Shen Building

Chair: Seung-Joo Lee

10:00-11:00 Kimyeong Lee (KIAS, Korea)

Instantons and Instanton (self-dual) Strings in Higher Dimensional Theories

11:00-12:00 Jaemo Park (Postech Korea)

Understanding the self-dual strings in 6-d string theories

12:00-14:00 Lunch

Chair: Pierre Dechant

14:00-15:00 Mengchwan Tan (National University, Singapore)

Supersymmetric gauge theory with surface defects and geometric invariants in various dimensions

15:00-15:30 Break

15:30-16:30 Seung-Joo Lee (Virginia Tech, USA)

Calabi-Yau Geometry, Multiple Fibrations, and Dualities

16:30-17:30 Wenzhe Yang (Oxford University, UK)

TBA

18:30 Dinner

2 August, Wednesday

Lecture Hall 216, Shiing-Shen Building

Chair: Sanjaye Ramgoolam

10:00-11:00 Philip Candelas (Oxford University, UK)

TBA

11:00-12:00 Minhyong Kim (Oxford University, UK & KIAS, Korea)

On gauge fields and Galois representations

12:00-14:00 Lunch

Free Afternoon

3 August, Thursday

Lecture Hall 216, Shiing-Shen Building

Chair: Raimundas Vidunas

10:00-11:00 Sanjaye Ramgoolam (Queen Mary, University of London, UK)

CFT4, TFT2 and Calabi-Yau orbifolds

11:00-12:00 Terry Gannon (University of Alberta, Canada)

TBA

12:00-14:00 Lunch

Chair: Nathan Broomhead

14:00-15:00 Yvonne Geyer (IAS, Princeton, USA)

TBA

15:00-15:30 Break

15:30-16:30 Adriana Salerno (Bate College, USA)

TBA

16:30-17:30 Raimundas Vidunas (Osaka University, Japan)

TBA

18:30 Dinner

4 August, Friday

Lecture Hall 216, Shiing-Shen Building

Chair: Vishnu Jejjala

12:00-14:00 Lunch

10:00-11:00 Burt Ovrut (University of Pennsylvania, USA)

Standard Model in String Theory

11:00-12:00 Minxin Huang (USTC, China)

Refined BPS invariants of 6d SCFTs from anomalies and modularity

Chair: Minxin Huang

14:00-15:00 Nathan Broomhead (Plymouth University, UK)

Derived categories and stability conditions

15:00-15:30 Break

15:30-16:30 Pierre Dechant (University of York, UK)

Root systems and Clifford algebras:

from symmetries of viruses to E_8 and ADE correspondences

16:30-17:30 Vishnu Jejjala (Witts University, South Africa)

On the Shape of Things

18:30 Dinner

5 August, Saturday

Departure Day

**Thank you very much and we welcome you all to visit
the Chern Institute of Mathematics again!**

Titles and Abstracts

Speaker: Nathan Broomhead (Plymouth University, UK)

Title: Derived categories and stability conditions

Abstract: Since their introduction in the 1970s, derived categories have become central to much research, both as objects in their own right, but particularly as tools which allow connections to be made between different areas, including algebraic geometry, representation theory and theoretical physics. In this talk I will give some examples of this interaction, before outlining some of my current work on spaces of Bridgeland stability conditions of certain derived categories.

Speaker: Scott Carnahan

Title: Generalized Monstrous Moonshine

Abstract: The subject known as Monstrous Moonshine began in the 1970s, when numerical computations suggested a relationship between representations of the monster simple group and modular functions obeying a genus zero property. The classical theories of modular functions on the complex upper half-plane and finite simple groups of symmetries were not previously thought to be closely related, and the initial observations were viewed with some skepticism. However, Borcherds's 1992 proof of the Conway-Norton Monstrous Moonshine Conjecture, together with some preceding work, showed that ideas from theoretical physics, in particular conformal field theory, provide a bridge that links the two fields. Generalized Monstrous Moonshine is an enhancement proposed by Norton in 1987 that, from a physical standpoint, describes all possible twisted sectors of a conformal field theory with monster symmetry. This conjecture was recently proved following a program outlined by Hoehn.

Speaker: Pierre Dechant (York University, UK)

Title: Root systems and Clifford algebras: from symmetries of viruses to E_8 and ADE correspondences

Abstract: In this talk I present a new take on reflection symmetries. Many viruses have icosahedrally symmetric surface structures, since they build their protein capsids from identical geometric subunits for reasons of genetic economy. I briefly review recent work (with Reidun Twarock and Celine Boehm) to try and extend this symmetry principle also to the interior of viruses and carbon onions (nested fullerenes) via suitable notions of affine extensions of non-crystallographic Coxeter groups. This work shed new light on structure and assembly of viruses and fullerenes; in particular, it now emerges that the RNA contained within the virus capsid is often crucial to the capsid assembly process

via specific interactions between the RNA and the capsid protein, which are orchestrated by the symmetry.

I have argued that in such reflection group settings (a vector space with an inner product) Clifford algebras are very natural objects to consider and in fact provide a very simple reflection formula. The Clifford algebra of 3D is 8-dimensional, whilst the subspace of spinors is 4-dimensional, thus relating the geometries of 3, 4 and 8 dimensions. Applying this Clifford framework to 3D root systems has therefore allowed me to construct the famous exceptional 8-dimensional root system/Lie algebra E_8 from the icosahedron, as well as a proof that each 3D root system induces a corresponding 4D root system, whilst the 2D root systems $I_2(n)$ (the regular $2n$ -gons) are self-dual. In particular, in this construction the Trinity of irreducible 3D root systems (A_3, B_3, H_3) (corresponding to tetrahedral, octahedral and icosahedral symmetry) gives rise to the Trinity of exceptional 4D root systems (D_4, F_4, H_4) . The exceptional root systems can thus be viewed as intrinsically three-dimensional phenomena. Finally, including the remaining 2D and 3D root systems $I_2(n)$ and $I_2(n) \times A_1$ in the correspondence establishes ADE/McKay correspondences relating the 2D/3D root systems, 4D root systems (subgroups of $SU(2)$) and ADE root systems/Lie algebras.

Speaker: Feng Yue (Peking U, China)

Title: Formality of Fukaya category

Abstract: Fukaya category describes A_∞ structures of symplectic manifolds, which is a key geometric invariant. Unfortunately the original approach is extremely hard to compute. In this talk we propose a new formulation of this story, whose main ingredients are perverse sheaves, a categorical analogue of perverse sheaf, microlocal category and formality of Kontsevich operads. I'll also discuss local-global compatibility, which is realized by factorization algebra and small sites on Ran spaces. If time permits, some p -adic speculation. This is based on my work in progress.

Speaker: Minxin Huang (USTC, China)

Title: Refined BPS invariants of 6d SCFTs from anomalies and modularity

Abstract: F-theory compactifications on appropriate local elliptic Calabi-Yau manifolds engineer six dimensional superconformal field theories and their mass deformations. The partition function Z_{top} of the refined topological string on these geometries captures the particle BPS spectrum of this class of theories compactified on a circle. Organizing Z_{top} in terms of contributions Z_β at base degree β of the elliptic fibration, we find that these, up to a multiplier system, are meromorphic Jacobi forms of weight zero with modular parameter the Kaehler class of the elliptic fiber and elliptic parameters the couplings and mass parameters. The indices with regard to the multiple elliptic parameters are fixed by the refined holomorphic anomaly equations, which we show to be completely

determined from knowledge of the chiral anomaly of the corresponding SCFT. We express $Z\beta$ as a quotient of weak Jacobi forms, with a universal denominator inspired by its pole structure as suggested by the form of Z_{top} in terms of 5d BPS numbers. The numerator is determined by modularity up to a finite number of coefficients, which we prove to be fixed uniquely by imposing vanishing conditions on 5d BPS numbers as boundary conditions. We demonstrate the feasibility of our approach with many examples, in particular solving the E-string and M-string theories including mass deformations, as well as theories constructed as chains of these. We make contact with previous work by showing that spurious singularities are cancelled when the partition function is written in the form advocated here. Finally, we use the BPS invariants of the E-string thus obtained to test a generalization of the Goettsche-Nakajima-Yoshioka K-theoretic blowup equation, as inspired by the Grassi-Hatsuda-Marino conjecture, to generic local Calabi-Yau threefolds.

Speaker: Vishnu Jejjala (Wits University, South Africa)

Title: "On the Shape of Things"

Abstract: We explore the question of which shape a manifold is compelled to take when immersed in another one, provided it must be the extremum of some functional. We consider a family of functionals which depend quadratically on the extrinsic curvatures and on projections of the ambient curvatures. These functionals capture a number of physical setups ranging from holography to the study of membranes and elastica. We present a detailed derivation of the equations of motion, known as the shape equations, placing particular emphasis on the issue of gauge freedom in the choice of normal frame. We apply these equations to the particular case of holographic entanglement entropy for higher curvature three dimensional gravity and find new classes of entangling curves. In particular, we discuss the case of New Massive Gravity where we show that non-geodesic entangling curves have always a smaller on-shell value of the entropy functional. Then we apply this formalism to the computation of the entanglement entropy for dual logarithmic CFTs. Nevertheless, the correct value for the entanglement entropy is provided by geodesics. Finally, we discuss the importance of these equations in the context of classical elastica and comment on terms that break gauge invariance.

Speaker: Minhyong Kim (Oxford University UK & KIAS, Korea)

Title: On gauge fields and Galois representations

Abstract: Representations of Galois groups of rings of integers in algebraic number fields have been central to research in algebraic number theory since the 1960s, from the study of Diophantine equations to the theory of motives and the Langlands programme. In the realm of arithmetic geometry, they are precise

analogues of flat connections in geometry. In this lecture, I will review this analogy, as well as the analogy between knots and primes. We will then describe some examples of 'path-integral quantisation', where the integration over gauge fields is replaced by an integral over representations.

Speaker: Kimyeong Lee (KIAS, Korea)

Title: Instantons and Instanton (self-dual) Strings in Higher Dimensional Theories

Abstract: Dyon instanton solitons in 5d and selfdual strings in 6d have played a crucial role in our understanding of the 5,6d superconformal field theories and 6d little string theories. In this talk, I would high-lights the knowns and unknowns of instanton physics.

Speaker: Seung-Joo Lee (CERN)

Title: Calabi-Yau Geometry, Multiple Fibrations, and Dualities

Abstract:

We study the ubiquity of multiple fibration structures in known constructions of Calabi-Yau manifolds and explore the role they play for string dualities. Upon sketching some relevant tools, we analyze the F-theory effective theories associated to multiple elliptic fibrations in a given resolved Calabi-Yau manifold and relate them via the M-/F-theory correspondence. Explicit geometric examples will feature higher-rank Mordell-Weil groups and non-flat fibrations. In addition, we also investigate multiple nested structures of K3- and elliptic fibrations in the context of heterotic/F-theory duality. Finally, a systematic approach to classifying/enumerating genus-one fibrations will be addressed for all Complete Intersection Calabi-Yau threefolds.

Speaker: Masahiko Miyamoto (Tsukuba University, Japan)

Title: Twelfth Night and Super Conformal Algebra of central charge $6c_2$

Abstract: In my talk, we will show that for each element g of the largest Mathieu group M_{24} , twisted elliptic genus $Z_g(\tau, z)$ of a K3 surface is really given as a trace function of g -invariant $N=4$ super conformal algebra of central charge $6c_2$ on a M_{24} -module.

Speaker: Burt Ovrut (Upenn, USA)

Title: The Standard Model in String Theory

Abstract:

The Standard Model (SM) of particle physics and the discovery of the Higgs boson will be reviewed, a brief description of $N=1$ supersymmetry presented and the Standard Model generalized to the Minimally Supersymmetric SM. The relevance of the MSSM to gravitation and its relationship to superstring theory will be discussed. A more mathematical description of how the MSSM can arise in "heterotic" superstring theory, and the detailed particle physics phenomenology that this predicts, will be given. Finally, it will be shown that for sufficiently large spontaneous breaking of supersymmetry, a natural theory of cosmological "inflation" can be found which satisfies all of the Planck 2015 data.

Speaker: Jaemo Park (Postech, Korea)

Title: Understanding the self-dual strings in 6-d string theories.

Abstract: Understanding the non-critical tensionless strings in six dimensional string theories has been a long standing puzzle. I report the progress made in recent years. For some examples, one can define tensionless string as the low energy limit of a two dimensional gauge theory. Other theoretical issues will be discussed as well.

Speaker: Sanjaye Ramgoolam (Queen Mary, University of London, UK)

Title: CFT4, TFT2 and Calabi-Yau orbifolds

ABS: TBA

Title: Arithmetic, Hypergeometric Functions, and Mirror Symmetry

Abstract: Mirror symmetry predicts surprising geometric correspondences between distinct families of algebraic varieties. In some cases, these correspondences have arithmetic consequences. Among the arithmetic correspondences predicted by mirror symmetry are correspondences between point counts over finite fields, and more generally between factors of their Zeta functions. In this talk, we will introduce these topics and describe these correspondences. Finally, we will discuss how all of this relates to hypergeometric functions and hypergeometric motives. This is joint work with: Charles Doran (University of Alberta, Canada), Tyler Kelly (University of Cambridge, UK), Steven Sperber (University of Minnesota, USA), John Voight (Dartmouth College, USA), and Ursula Whitcher (American Mathematical Society, USA).

Speaker: Mengchwan Tan (National University Singapore)

Title: Supersymmetric gauge theory with surface defects and geometric invariants in various dimensions.

Abstract: We will explain how a certain four-dimensional supersymmetric gauge theory with surface defects can be used to formulate geometric invariants in various dimensions which (i) count the number of surfaces that can be embedded in a four-manifold and (ii) classify knots in a three-submanifold, among other things. As an offshoot, highly-nontrivial mathematical identities involving these invariants lend themselves to simple and elegant physical derivations, whilst novel, hitherto unexpected identities are also suggested. Our story is one of many examples in quantum field and string theory which illustrates the unreasonable effectiveness of physics in mathematics, in particular, geometry and topology.

Speaker: Yan Xiao (City, University of London, UK)

Title: A New Dimer Technology and Quiver Gauge Theories

Abstract: The connection between quivers whose representation varieties are Calabi-Yau and the combinatorics of bipartite graph on Riemann surfaces have initiated a rich subject between gauge theories and geometry. In this talk, I will review the basic concepts in quivers and dimers, mainly from a physical point of view. In the end, we will introduce a new dimer technology that has been recently used to produce a comprehensive catalogue of brane-tiling from toric diagrams of various areas.