Contents

1 Meer Ashwinkumar **2**

2 David Berman **2**

3 Sergei Gukov **3**

4 Fei Han **3**

5 Hyungrok Kim **3**

6 Georgios Korpas **4**

7 Neil Lambert **4**

8 Si Li **5**

9 Ioana Coman Lohi **5**

10 Hisham Sati **6**

11 Urs Schreiber **6**

12 Eric Sharpe **8**

13 Meng-Chwan Tan **8**

14 Alessandro Tanzini **9**

15 Richard Thomas **9**

16 Mathai Varghese **9**

17 Junya Yagi **10**

18 Max Zimet **10**

Abstracts

Conference on String and M-Theory:
The New Geometry of the 21st Century – II

29 November–3 December 2021

1 Meer Ashwinkumar

Kavli Institute for the Physics and Mathematics of the Universe, Japan
Matrix regularization of classical Nambu brackets and super p-Branes

Abstract

We present an explicit matrix algebra regularization of the algebra of volume-preserving diffeomorphisms of the n-torus. That is, for n-tori and (n-1)-tori where n is even, we approximate the corresponding classical Nambu brackets using $sl(N^{(}n/2), C)$-matrices equipped with the finite bracket given by the completely anti-symmetrized matrix product, such that the Nambu brackets are retrieved in the N $\to \infty$ limit. We then apply this approximation to the super 4-brane in 9 dimensions and present a regularized action in analogy with the matrix regularization of the supermembrane. This action exhibits a reduced gauge symmetry that we discuss from the viewpoint of L_∞-algebras in a slight generalization to the construction of Lie 2-algebras from Bagger-Lambert 3-algebras.

2 David Berman

Queen Mary University of London, UK
The double copy of M-theory

Abstract

I will introduce the double copy formalism as a map between GR and Yang-Mills. Then after a quick review of exceptional field theory I will use a generalised Kerr Schild Ansatz for exceptional field theory to provide a linearisation of M-theory. We will then map this over to a field theory and examine the Membrane solution from this perspective.

3 Sergei Gukov

California Institute of Technology, USA
Higher-form symmetries in TQFTs and Coulomb branches

Abstract

This talk can be viewed as a bridge between two topics that have been actively explored in recent years. One involves the study of generalized (higher) symmetries in QFTs and TQFTs. And, the second topic is the study of strongly-coupled dynamics in SQCD-like theories via the geometry of their Coulomb branches.

4 Fei Han

National University of Singapore, Singapore
Characteristic numbers and index theoretic invariants for 24 dimensional string manifolds

Abstract

A manifolds M is called string manifold is its free loop space LM is spin. There are many studies on the string geometry. Dimension 24 is in particular interesting for string geometry. In the talk, I will report our work on the study of characteristic numbers and index theoretic invariants for 24 dimensional string manifolds and string cobordism following Mahowald-Hopkins. This represents our joint work with Ruizhi Huang.

5 Hyungrok Kim

The Maxwell Institute for Mathematical Sciences, UK
Geometric and non-geometric T-duality using higher gauge symmetries

Abstract

String theory admits compactifications not describable by ordinary Riemannian geometry, known as T-folds and R-spaces, whose existence can be deduced from ordinary geometric compactifications by T-duality. Its topological sector can be described (cf. Nikolaus–Waldorf 2020) by higher nonabelian gauge symmetries, but the kinematics of such gauge fields are plagued by a problem ("fake flatness") that renders the dynamics trivial. Only certain higher gauge symmetries (e.g. tensor hierarchies — Borsten–Kim–Saemann 2021) admit consistent dynamics in the form of an "adjustment" (Saemann–Schmidt 2020). We show that the higher gauge symmetry of T-duality is healthy in this sense: this provides a consistent description of T-dual dynamics even in topologically nontrivial and possibly non-geometric backgrounds.
Based on ongoing joint work with Christian Saemann.

6 Georgios Korpas

Czech Technical University in Prague, Prague
Using the u-plane integral to probe the A-model

Abstract

The u-plane integral is the contribution of the Coulomb branch to the path integral and correlation functions of low energy topological $N = 2$ gauge theory on a compact four-manifold. We revisit the u-plane integral on arbitrary non-simply connected four-manifolds. We derive mock modular properties for it that allow to probe correlation functions of the topological A-model, bridging analytic number theory and enumerative geometry.

Based on work with Johannes Aspman, Elias Furrer, Zhi-Cong On and Meng-Chwan Tan.

7 Neil Lambert

King's College London, UK
Path-integral formulation of Chiral partition functions

Abstract

We exploit the unique features of the action for self-dual forms proposed by Sen to compute the partition function of a chiral boson in two-dimensions directly from a path-integral. The results provide a manifestly holomorphic and unambiguous construction of the partition function, with no need for holomorphic factorisation. We also discuss how these results can be extended, most notably to self-dual three-forms in six-dimensions.

8 Si Li

Tsinghua University, China
Elliptic chiral homology and quantum master equation

Abstract

We present an effective BV quantization theory for chiral deformation of two dimensional conformal field theories. We explain a connection between the quantum master equation and the chiral homology for vertex operator algebras. As an application, we construct correlation functions of the curved beta-gamma/b-c system and establish a coupled equation relating to chiral homology groups of chiral differential operators. This can be viewed as the vertex algebra analogue of the trace map in algebraic index theory.

9 Ioana Coman Lohi

University of Amsterdam, Netherlands
Quantum modularity of higher rank homological blocks

Abstract

A recently proposed class of topological 3-manifold invariants $\hat{Z}[M_3]$ which admit series expansions with integer coefficients has been the focal point of intense research over the past few years. Their definition has its origins in the computation of BPS spectra of 3d $\mathcal{N} = 2$ theories $T[M_3]$ which are associated to 3-manifolds M_3 by a compactification on M_3 of the 6d $\mathcal{N} = (2, 0)$ SCFT living on a stack of M5 branes. Under the 3d-3d correspondence, the functions $\hat{Z}$ have been related to other topological invariants, for example the WRT invariant of M_3. Subsequently, $\hat{Z}[M_3]$ have also been shown to possess interesting number-theoretic features, proving to be quantum modular

forms in cases where $T[M_3]$ have gauge group $SU(2)$. After reviewing these developments, here we explore certain higher rank extensions and emerging features of the corresponding $\hat{Z}$ invariants.

10 Hisham Sati

New York University Abu Dhabi, United Arab Emirates
Mysterious triality in M-theory

Abstract

Mysterious duality has been discovered by Iqbal, Neitzke, and Vafa as a correspondence between certain symmetry patterns in M-theory on tori T^k and del Pezzo surfaces B_k, both governed by the root system of the exceptional Lie series E_k, $k \leq 8$.

We extend this duality between algebraic geometry and physics to a triality, which includes algebraic topology. Starting with Hypothesis H that the M-theory fields and their dynamics are captured by the 4-sphere, the iterated cyclic loop spaces $\mathcal{L}_c^k S^4$ that arise in the dimensional reduction on T^k form a sequence of spaces, within which we discover the E_k symmetry pattern via rational homotopy theory. This allows for a demystification of the duality between physics and mathematics by transferring it to the mathematical realm as a duality between algebraic geometry and algebraic topology.

Our approach allows for extending both mysterious duality and triality to the Kac-Moody case, $k \geq 9$, and for physical and topological interpretations of several prominent statements in algebraic geometry, including the famous 27 lines on a cubic.

This is joint work with Alexander Voronov.

11 Urs Schreiber

NYU, Abu Dhabi; and Czech Academy of Sciences, Prague
Proper Orbifold Cohomotopy for M-Theory

Abstract

M-theory folklore has it that all quasi-realistic QCD-like quantum physics is realized at or inside super-spacetime orbi-singularities of intersecting black

M5/M2-branes, whose higher magnetic flux threads an ambient smooth bulk super-spacetime subject to a long list of subtle differential- and algebro-topological constraints. Despite an intriguing web of plausibility arguments and consistency checks that have been amassed for this picture, it has remained unclear what any of this really means mathematically – notably what putative M-theory actually predicts, with any certainty, for observable physics – be it in its application to confined hadronic matter (holographic QCD), or to quantum-supreme solid states (holographic CMT), not to speak of the more traditional but less tangible application to quantum gravity.

The issue with the mathematical foundations of M-theory had been prophesized early on (E. Witten in: Davis & Brown, CUP 1988, p. 95, 102): "String theory at its finest should be a new branch of geometry ... developed in the twenty-first or twenty-second century ... that fell by chance into the twentieth century".

With the 21st century now well under way, this talk surveys a new branch of mathematical geometry which has emerged over the last years, in joint work with Hisham Sati, and which *provably* exhibits a fair number of the subtle phenomena expected in M-theory on fluxed orbifold spacetimes:

This "*Differential Cohomotopy in a Singular-Cohesive ∞-Topos*" operates close to novel homotopy-theoretic foundations for mathematics itself (modal homotopy type theory) and provides a rigorous but charmingly intuitive axiomatics of geometric qualities that transparently control elaborate higher geometric entities such as the twisted equivariant differential generalized cohomology of G-structured super-orbifolds which should give mathematical meaning to quantized M-brane charges and C-field fluxes.

This talk means to give some idea of the basics and the results, following recent developments (arXiv:2008.01101, arXiv:1909.12277, arXiv:2011.06533, arXiv:1812.09679); for more pointers see:
ncatlab.org/schreiber/show/Proper+Orbifold+Cohomotopy+for+M-Theory

Further evidence for the naturally resulting "Hypothesis H" that this new geometry is indeed part of the previously missing mathematical foundations of M-theory will be discussed in the lecture by Hisham Sati in the school the week before this conference.

12 Eric Sharpe

Virginia Tech, USA
Application of decomposition to anomaly resolution

Abstract

In this talk we will discuss a method of anomaly resolution due to Wang-Wen-Witten in the special case of (1+1) dimensional theories. Briefly, for our purposes, Wang-Wen-Witten argued that an ill-defined anomalous orbifold [X/G] could be resolved by extending G to a larger group and adding suitable phases. We analyze this process from the perspective of decomposition, a property of (1+1)-dimensional theories with "one-form symmetries" first described in 2006. Examples of such theories include orbifolds with trivially-acting subgroups, of which the extensions of [X/G] are examples. After a review of decomposition, we will see that decomposition implies that in (1+1) dimensions, the Wang-Wen-Witten procedure results in orbifolds that are equivalent to disjoint unions of orbifolds of X by explicitly nonanomalous subgroups of G, giving a simple concrete understanding of the physics of the Wang-Wen-Witten method.

13 Meng-Chwan Tan

National University of Singapore, Singapore
Unifying lattice models, links and quantum geometric Langlands via Branes in string theory

Abstract

I will explain how, starting with a stack of D4-branes ending on an NS5-brane in type IIA string theory, one can, via T-duality and the topological-holomorphic nature of the relevant worldvolume theories, relate (i) the lattice models realized by Costello's 4d Chern-Simons theory, (ii) links in 3d analytically-continued Chern-Simons theory, (iii) the quantum geometric Langlands correspondence realized by Kapustin-Witten using 4d N = 4 gauge theory and its quantum group modification, and (iv) the Gaitsgory-Lurie conjecture relating quantum groups/affine Kac-Moody algebras to Whittaker D-modules/W-algebras. This furnishes, purely physically via branes in string theory, a novel bridge between the mathematics of integrable systems, geometric topology, geometric representation theory, and quantum algebras.

14 Alessandro Tanzini

Scuola Internazionale Superiore di Studi Avanzati, Italy
Surface operators and simple instanton counting

Abstract

We show that the partition functions of 4d supersymmetric gauge theories with 8 supercharges in presence of surface defects obey tt* equations for a suitable isomonodromic deformation problem, and we comment on its M-theory origin. The solution to these equations provides new recursion relations for instanton counting for all simple groups from A to E. The uplift to 5d is a discrete flow generated by automorphisms of the associated BPS quiver. We show that for a class of theories, the 4d reduction of these discrete flows displays an intriguing new relation with Argyres-Douglas SCFTs.

15 Richard Thomas

Imperial College London, UK
Nonabelian DT theory from abelian

Abstract

Fix a Calabi-Yau 3-fold X. Its DT invariants count stable bundles and sheaves of arbitrary rank on X. The generalised DT invariants of Joyce-Song count semistable bundles and sheaves on X. I will describe work with Soheyla Feyzbakhsh showing these generalised DT invariants in any rank r can be written in terms of rank 1 invariants.
By the MNOP conjecture these rank 1 "abelian" invariants are determined by the GW invariants of X. Along the way we also express rank r DT invariants in terms of invariants counting D4-D2-D0 branes: rank 0 sheaves supported on surfaces in X. These invariants are predicted by S-duality to be governed by (vector-valued, mock) modular forms.

16 Mathai Varghese

University of Adelaide, Australia
T-Duality, Jacobi forms and Witten Gerbe modules

Abstract

We extend the T-duality Hori maps in [BEM03], inducing isomorphisms of twisted cohomologies on T-dual circle bundles, to graded Hori maps and show that they induce isomorphisms of two-variable series of twisted cohomologies on the T-dual circle bundles, preserving Jacobi form properties. The composition of the graded Hori map with its dual equals the Euler operator. We also construct Witten gerbe modules arising from gerbe modules and show that their graded twisted Chern characters are Jacobi forms under an anomaly vanishing condition on gerbe modules, thereby giving interesting examples. Time permitting, we also discuss the action Courant algebroids in this context and its action on Jacobi differential forms. This is joint work with Fei Han (NUS)

17 Junya Yagi

Tsinghua University, China
Superspin chains from superstring theory

Abstract

I will discuss superalgebra generalizations of the Bethe/gauge correspondence between 2d N=(2,2) quiver gauge theories and rational spin chains. I will give a derivation of the correspondence by mapping relevant brane constructions to 4d Chern-Simons theory via string dualities. Based on joint work with Nafiz Ishtiaque, Seyed Faroogh Moosavian and Surya Raghavendran.

18 Max Zimet

Harvard University, USA
K3 metrics

Abstract

I will explain a physically motivated construction of Ricci-flat K3 metrics, which gives the first examples of Ricci-flat metrics on compact non-toroidal Calabi-Yau manifolds. I will also relate it — both physically and mathematically — to a second such construction, which is as yet not completely

explicit: the missing data is the BPS index of a little string theory on T^2. In particular, I will show that these discrete invariants may be extracted from the metrics produced by the first approach.