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# Abstracts

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

22–26 November 2021

## 1 Yang-Hui He

*London Institute, Royal Institution, UK*
Universes as bigdata: from geometry, to physics, to machine-learning

Abstract

We briefly overview how historically string theory led theoretical physics first to algebraic/differential geometry, and then to computational geometry, and now to data science. Using the Calabi-Yau landscape - accumulated by the collaboration of physicists, mathematicians and computer scientists over the last 4 decades - as a starting-point and concrete playground, we then launch to review our recent programme in machine-learning mathematical structures and address the tantalizing question of how AI helps doing mathematics, ranging from geometry, to representation theory, to combinatorics, to number theory.

## 2 Neil Lambert

*King's College London, UK*
Update on actions and path integrals for the (2,0) theory

Abstract

Six-dimensional conformal field theories play a prominent role in current research. In M-theory they arise from the dynamics of M5-branes through

the so-called (2,0) theory. However such theories do not admit traditional Lagrangian descriptions as a result our understand is severely limited. After a review of the problems I will describe work on constructing actions and thereby path integral formulations which have a reduced SU(1,3)xSO(5) subset of the bosonic symmetries and 3/4 of the supersymmetries. We will argue that, in analogy to the ABJM description of M2-branes, the remaining symmetries arise non-perturbatively in the path-integral.

# 3 Marcos Marino

*University of Geneva, Switzerland*
Resurgence, quantum topology and strings

Abstract

Quantum field and string theories often lead to perturbative series which encode geometric information. In this lecture I will argue that, in the case of complex Chern-Simons theory and topological string theory, these perturbative series secretly encode integer invariants, related in some cases to BPS counting. The framework which makes this relation possible is the theory of resurgence, where perturbative series lead to additional non-perturbative sectors. I'll show that the integer invariants arise as Stokes constants of the resulting resurgent structure, in what we call a "peacock pattern". I will illustrate these claims with explicit examples related to hyperbolic knots and toric Calabi-Yau threefolds. Factorization in (anti)holomorphic blocks and the correspondence between topological strings and spectral theory turn out to play an important role in the story.

# 4 Christian Saemann

*Heriot-Watt University, UK*
Adjusted higher gauge theory and applications in physics

Abstract

The Kalb-Ramond B-field that is ubiquitous in string theory is part of the connective structure of a gerbe, a higher or categorified version of a principal

bundle. In this lecture, I review the mathematics required to define categorified principal bundles. I also introduce adjusted connective structures on them, which requires a departure from the usual discussion available in the literature. Finally, I give a number of applications of adjusted connective structures in physics, in particular in the context of tensor hierarchies of gauged supergravities, the description of M5-branes, and in an elegant description of T-duality.

# 5 Hisham Sati

*New York University Abu Dhabi, United Arab Emirates*
Hypothesis H and the (Co)homotopy approach to M-theory and string theory

Abstract

Mathematics, in particular homotopy theory, has been playing a prominent role in shedding light on the structures underlying M-theory and string theory. We will survey the consistent approach to M-theory based on (Co)homotopy theory, in which the 4-sphere plays a central role through "Hypothesis H" that the generalized cohomology theory underlying M-theory is twisted Cohomotopy theory. We will describe the web of consistency conditions that this hypothesis has passed, detecting a list of subtle effects expected to arise both in M-theory and its reduction to string theory, in addition to generally providing a solid ground, a unifying theme, and a clarifying perspective.

# 6 Ashoke Sen

*Harish-Chandra Research Institute, Prayagraj, India*
D-instanton amplitudes in string theory

Abstract

I shall review the problems in computing D-instanton contribution to string amplitudes using the usual world-sheet methods, and recent progress in overcoming these difficulties using insights from string field theory.

# 7 Eric Sharpe

*Virginia Tech, USA*

An introduction to decomposition

Abstract

In this lecture we will review 'decomposition', which states that a quantum field theory in d spacetime dimensions with a (d-1)-form symmetry is equivalent to ("decomposes into") a disjoint union of other quantum field theories, known in this context as "universes." Decomposition explains and relates several physical properties of these theories. For one example, the existence of a (d-1)-form symmetry restricts allowed instantons, and this restriction is implemented in decomposition as a "multiverse interference effect" between contributions from universes. Examples of two-dimensional theories which decompose include gauge theories with center-invariant matter and orbifolds with trivially-acting subgroups. After reviewing higher-form symmetries and decomposition in general, we will discuss a few examples in detail to illustrate properties of decomposition and some of its applications, which include Gromov-Witten invariants, phases of gauged linear sigma models, elliptic genera of pure gauge theories, and anomaly resolution in orbifolds.