Tsinghua-Tokyo workshop on Calabi-Yau, titles and abstracts

Caucher Birkar (YMSC/BIMSA)
Title: Effective algebraic geometry
Abstract: There are many existence results in algebraic geometry (and more generally mathematics) in which a number or structure is proved to exist. It is often desirable if one can make such statements effective or explicit in the sense that the number or structure is effectively computable. In this talk we will discuss some problems in this direction.

Sergio Cecotti (BIMSA)
Title: Calabi-Yau methods in QFT
Methods and results developed in the study of Calabi-Yau moduli and mirror symmetry can be used in the construction/classification of 4d N=2 SCFTs. Indeed the underlying periods satisfy the same differential conditions. In this talk I will discuss some applications of this strategy to QFT problems.

Will Donovan (YMSC)
Title: Resolution, smoothing and derived symmetries
Abstract: Given a singularity with a crepant resolution, a symmetry of the derived category of coherent sheaves on the resolution may often be constructed, with applications to homological mirror symmetry and enumerative geometry. I relate such constructions to the derived category of a smooth ambient space for the given singularity. This builds on previous results with Segal, and is inspired by work of Bodzenta-Bondal.

Kenji Fukaya (Stony Brook)
Title: Floer homology of exact Lagrangian submanifold of cotangent bundle and generating function.
Abstract: Lagrangian submanifold of cotangent bundle is studied in two different ways. One is usual Floer homology based on pseudo-holomorphic curve. The other is a finite dimensional Morse theory of a function called generating function. In this talk based on a joint work with A. Daemi I will explain they are equivalent. There are several mathematical works which are related to this point such as immersed Lagrangian Floer theory of Akaho-Joyce, Legendrian contact homology by Chekanov-Eliashberg. A relation to the story of micro local sheaf is also mentioned.

Kentaro Hori (IPMU)
Title: Strong/weak CY/CY correspondence and the grade restriction rule
Abstract: 2d (2,2) supersymmetric gauge linear sigma models provide an explanation of various correspondences including McKay correspondence and Calabi-Yau/Landau-Ginzburg correspondence. When applied to B-branes, they provide derived equivalence for transport between phases as well as autoequivalences for monodromies around singular points. The grade restriction rule plays the central role. In the talk, I describe that in the case of strong/weak Calabi-Yau/Calabi-Yau correspondence, where Seiberg duality also plays an important role.

Shinobu Hosono (Gakushuin)
Title: BCOV cusp forms of lattice polarized K3 surfaces
Abstract: In 1992, Cecotti and Vafa introduced a new index for N=2 supersymmetric

theories, which generalizes the Witten index. For N=2 supersymmetric theories from Calabi-Yau manifolds, this new index is known as BCOV (Bershadsky, Ceccoti, Ooguri and Vafa) formula. In particular, for Calabi-Yau threefolds, this BCOV formula is well-known as the generating function of Gromov-Witten invariants of genus one. In this talk, I will consider the BCOV formula for lattice polarized K3 surfaces. There is no Gromov-Witten invariants in the BCOV formula for K3 surfaces, however, we will find some nice cusp forms (which we call BCOV cusp forms) on the relevant period domains. As by-products, we also find K3 differential operators for all the genus zero groups of type $\Gamma_0(n)_+$. This is a joint work with Atsushi Kanazawa (mathAG: arXiv:2303.04383 published in Adv. Math. 434(2023))

Yukari Ito (IPMU)
Title: Crepant resolution of Calabi-Yau singularities
Abstract: Let G be a finite subgroup of $SL(3, C)$, the quotient space $X := C^3/G$ has a singularity, and there exists a crepant resolution Y of X. The relation between algebra of the finite group and the geometry of the resolution was known as McKay correspondence and the topological Euler number is the same as the Orbifold Euler characteristic. In this talk, I would like to introduce several ways to explain the correspondence and I hope I can show you another connection with String theory.

Atsushi Kanazawa (Keio)
Title: Mirror symmetry and rigid structures of generalized K3 surfaces
Abstract: Inspired by works of Hitchin and Huybrechts, we introduce a formulation of mirror symmetry for generalized K3 surfaces by Mukai lattice polarizations. This formulation is compatible with Aspinwall-Morrison's description of the SCFT on a K3 surface, and fixes the problems in the conventional mirror symmetry for lattice polarized K3 surfaces. In particular, we settle the long-standing problem of mirror symmetry for singular K3 surfaces (also known as rigid K3 surfaces).

Kotaro Kawai (BIMSA)
Title: Manifolds with exceptional holonomy and mirrors of their submanifolds
Abstract: Manifolds with exceptional holonomy are considered to be analogous to the Calabi-Yau manifolds and have canonical calibrations. We can also consider the analogue of the mirror symmetry in the exceptional setting in a certain sense, and we can define the "mirrors" of calibrated submanifolds. They are also related to G2-instantons, which are higher dimensional analogue of ASD connections. In this talk, after introducing these outlines, I would like to explain the properties of the "mirrors" of calibrated submanifolds, such as the similarities to calibrated submanifolds and G2-instantons. I will also talk about the "mirrors" of minimal submanifolds and a certain monotonicity formula for them.

Hiroshi Ooguri (IPMU)
Title: Compact Calabi-Yau and Swampland
Abstract: In this talk, I will discuss recent applications of Calabi-Yau geometry to make low-energy predictions of quantum gravity. For the last couple of decades, it has become increasingly clear that the mathematical consistency of the unification of general relativity and quantum mechanics imposes non-trivial constraints on low-energy physics that cannot be captured by the standard paradigm of the Wilsonian effective theory. They

are called Swampland conditions. Since many consistent quantum gravity theories can be constructed by compactifications of string theory on compact Calabi-Yau manifolds, Calabi-Yau geometry has been used to test Swampland conditions and to discover new ones. In this talk, I will review the two basic Swampland conditions: the Distance Conjecture and the Weak Gravity Conjecture, and explain how the Hodge structure, the Gromov-Witten/Donaldson-Thomas invariants and the elliptic genera are used to test and clarify these conjectures. I will also discuss Swampland conditions in anti-de Sitter (AdS) space and their derivations using the AdS/CFT correspondence. If time permits, I will present my recent series of work on the symmetry resolution of the Hilbert spaces of conformal field theories, which is relevant for the Weak Gravity Conjecture in AdS.

Mauricio Romo (YMSC)
Title: B-brane transport for Determinantal Varieties and relation of Autoequivalences
Abstract: I will present some gauged linear sigma models (GLSM) related to determinantal Calabi-Yau (CY) varieties and show how different loops in its stringy Kahler moduli space M correspond to autoequivalences of the derived category of coherent sheaves of these CYs. Because of the nontrivial fundamental group of M, this correspondence gives interesting relations between functors implementing autoequivalences. I will illustrate this phenomenon in a family of examples which corresponds to nonabelian GLSMs where dim M=2 and whose geometric mirror is not known. This is joint work with Ban Lin.

Shoma Sugimoto (YMSC)
Title: On the Feigin-Tipunin construction
Abstract: Vertex algebra (VA) is a mathematical formulation of two-dimensional conformal field theory, and in the classical (rational) case, whose q-character gives a modular form. Recently, due to the relationship between VAs and higher dimensional field theories, the study of non-rational VAs has attracted a great deal of attention, but the examples and representation theory are not well known. On the other hand, S.Gukov and collaborators have introduced a quantum invariant of 3-manifolds called homological blocks and conjecture the existence of the corresponding non-rational VAs. In this talk, I will present my results and plans for a special case of this conjecture. In particular, I will explain that the homological block of a Seifert 3-manifold (corresponding to a false theta function) can be recovered if we can repeatedly apply the procedure called Feigin-Tipunin construction to a certain lattice VA (corresponding to a theta function).

Yukinobu Toda (IPMU)
Title: Quasi-BPS categories for K3 surfaces
Abstract: I will introduce the notion of quasi-BPS categories for K3 surfaces. They are defined to be certain admissible subcategories of derived categories of coherent sheaves of moduli stacks of semistable objects on K3 surfaces. The quasi-BPS categories are interesting at least in the following two aspects: (i) They categorify BPS cohomologies of K3 surfaces introduced by Davison et al; (ii) They give twisted categorical crepant resolutions of singular symplectic moduli spaces, which do not admit crepant resolutions except OG10. I will give PBW type semiorthogonal decompositions into categorical Hall products of quasi-BPS categories, and also discuss categorical χ-independence conjecture. This is a joint work with Tudor Padurariu.

Kazushi Ueda (Komaba)
Title: Moduli of Calabi-Yau manifolds as moduli of A-infinity structures
Abstract: In homotopy theory, equality is a structure rather than a property. In particular, associativity is a structure, and associativity as a structure in a homotopy-theoretic context is called an A-infinity structure. In the talk, I will discuss the moduli space of A-infinity structures on a fixed graded algebra, and its application to homological mirror symmetry. This is a joint work with Yanki Lekili.

Long Wang (Fudan)
Title: Morrison-Kawamata cone conjecture for Schoen varieties
Abstract: The cone conjecture of Morrison and Kawamata predicts the structure of nef and movable cones of Calabi-Yau varieties. The conjecture was motivated by both mirror symmetry and birational geometry. In this talk, I will first give an overview of this conjecture. Then I will report the joint work with Cécile Gachet and Hsueh-Yung Lin about the cone conjecture for the so-called Schoen varieties.

Junya Yagi (YMSC)
Title: Cluster algebras and 3D integrable systems
Abstract: Solutions of Zamolodchikov's tetrahedron equation define integrable 3D lattice models in statistical mechanics, just as solutions of the Yang-Baxter equation define integrable 2D lattice models. I will explain how we can construct solutions of the tetrahedron equation using quantum cluster algebras. This is based on joint work with Xiao-yue Sun, Rei Inoue, Atsuo Kuniba and Yuji Terashima.

Mayuko Yamashita (Kyoto)
Title: Topological Modular Forms and heterotic string theory
Abstract: In this talk I will explain my works on Topological Modular Forms (TMF), with an eye toward its relation with physics. TMF is an E-infinity ring spectrum which is conjectured by Stolz-Teichner to classify two-dimensional supersymmetric quantum field theories. In the joint works with Y. Tachikawa (a string-theoretist) I applied TMF to prove the absence of anomaly in heterotic string theory (https://arxiv.org/abs/2108.13542), and also found a physical significance of the Anderson duality in TMF (https://arxiv.org/abs/2305.06196). I am also going to mention the ongoing joint work with T. Johnson Freyd to give an explanation of 576-periodicity in SQFTs.

Wenbin Yan (YMSC)
Title: Tetrahedron instantons
Abstract: In this talk, we will discuss tetrahedron instantons, its construction from D1/D7 brane system in string theory and also definition in mathematics. The tetrahedron instanton partition function lies between the higher-rank Donaldson-Thomas invariants on Calabi-Yau threefolds and fourfolds, and can be computed exactly using 2d supersymmetric field theories, which provides a tool to study the duality between type IIA superstring theory and M-theory. I will also discuss the mathematical interpretation of this partition function. It admits a free field representation, suggesting the existence of a novel kind of symmetry which acts on the cohomology of the moduli spaces of tetrahedron instantons.

Shing-Tung Yau (YMSC/IPMU)
Title   LYZ equation and the CJY conjecture in Kähler geometry

Abstract The deformed Hermitian Yang-Mills (dHYM) equation is arised from the mirror symmetry. In this talk, a parabolic version of dHYM equation is introduced and the convergence is proved. This is a joint work with Jixiang Fu and Dekai Zhang. Remark: The equation has little to do with Yang-Mills and Yang was strongly against the concept of super symmetry, in any case, mirror symmetry coming from SYZ is the foundation for this equation.

Chenglong Yu (YMSC)
Title: Complex hyperbolic structures on moduli spaces of Calabi-Yau varieties
Abstract: There are many works realizing moduli spaces as quotients of complex hyperbolic balls, including Deligne-Mostow on moduli of points on projective line, Allcock-Carlson-Toledo on moduli of cubic surfaces and cubic threefolds, Kondo on moduli of curves of genus three and four, etc. A common feature of these construction is cyclic covering. In this talk, I will discuss constructions of Calabi-Yau varieties by cyclic covers and the complex hyperbolic structures on their moduli. Some of the examples are related to Deligne-Mostow varieties and induces commensurability relations among those ball quotients. The talk is based on joint work with Zhiwei Zheng.