Calabi–Yau Manifolds

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Castello dei Principi Capano

Book of Abstracts

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Welcome

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Backreaction of Fluxes on Calabi-Yau Metrics

We want to study warped IIB flux solutions using the setup of Giddings-Kachru-Polchinski. The solution leads to a warped metric with a warp factor that only depends on the internal coordinates. We want to study the functional form of the warp factor to investigate the singular bulk problem, which states that the warped region is not a small throat in the CY but almost the entire CY becomes strongly warped, which means that the supergravity solution is not well under control. I will explain the necessary steps to study this, which include approximating the CY metric with a neural network, finding imaginary self-dual flux solutions that stabilize the complex structure moduli close to a conifold point, constructing a basis of harmonic (2,1) forms (again using neural networks), and solving the differential equation for the warp factor (using a third neural network). We also discuss several improvements we made to minimize the numerical errors close to the singular regions.

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DT invariants of local CY 3-folds from Galois coverings of BPS quivers

After reviewing some basics of BPS state counting and of BPS quivers from a physics perspective, I will discuss new relationships between moduli spaces of quiver representations and between quiver DT invariants of distinct quivers which are related by so-called Galois covering functors. The new relationships are particularly interesting for quivers associated to canonical singularities that admit a NCCR.

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The 1, 2, 3, 4, … of Applying the Period Geometry of CY n-folds to Feynman Integrals

We explain how geometric and arithmetic properties of Calabi-Yau period geometry serve to make physical predictions in perturbative quantum field theory and general relativity.

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Mirror Symmetry of Abelian Fibered Calabi-Yau Manifolds

When constructing Calabi-Yau manifolds of dimension three, we often encounter elliptic or K3 fibered Calabi-Yau manifolds, and mirror symmetry of elliptic or K3 fibered Calabi-Yau manifolds is a well-studied subject from a variety of different interests. In contrast to this, except for those given by the fiber products of elliptic surfaces, Calabi-Yau threefolds fibred by abelian surfaces are rather rare to encounter. In this talk, I will describe mirror symmetry of a family of Calabi-Yau manifolds X fibered by (1,8)-polarized abelian surfaces found by Gross and Popescu in 2001, and studied by Pavanelli, with Hodge numbers $h^{1,1}(X) = h^{2,1} = 2$. We find many boundary points (LCSLs) in a suitably compactified parameter space of the family and identify them as a Fourier-Mukai partner of X, a birational model of X, and also a free quotient of X. We calculate Gromov-Witten invariants ($g \leq 2$) from each LCSL point and observe that these are written in terms of quasi-modular forms. This talk is based on a work with Hiromichi Takagi that appeared in CNTP (2022).

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Discussion

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Candidate de Sitter Vacua from Calabi-Yau Compactifications

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Elliptic Fibration Structure of Toric Hypersurface Calabi-Yaus

This talk will describe the results of a comprehensive analysis of manifest elliptic fibers in toric hypersurface Calabi-Yau threefolds. Previous work with Huang showed that all but 29,223 of the 474 million reflexive 4D polytopes in the Kreuzer-Skarke database admit a toric elliptic fiber. In recent work with Abbasi and Nally we have classified all toric fiber + base combinations. This talk will summarize this classification and describe a number of features including typical bases and fibers, high-rank SCFT's, singular bases without SCFT's, and implicit non-toric structure for gauge divisors and bases. A key take away is that elliptic fibrations provide a powerful framework for analyzing and understanding the structure of most known Calabi-Yau threefolds.

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Contributed Talks

These are shorter (15 minutes) informal talks, either using slides or chalk.

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Intrinsic Mirror Symmetry

Thanks to advances in logarithmic Gromov-Witten theory, we can now construct mirror partners canonically in the generality that birational geometry suggests. In the talk I will try to quickly introduce this intrinsic mirror construction and then comment on recent developments in proving both the original enumerative predictions and homological mirror symmetry in this setup.

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A Measure on the Supermoduli Space with Ramond Punctures

An essential ingredient in perturbative string theory is a certain measure on the moduli space $\mathcal{M}_g$ of curves. This measure is defined in terms of the Mumford isomorphism, which relates the canonical line bundle on $\mathcal{M}_g$ to the determinant of cohomology of the pushforward of the relative canonical line bundle on the universal curve. This pushforward, and thus also its determinant, has a natural hermitian metric given by integration. This metric can be expressed in terms of the period map. In superstring theory, this generalizes to a measure on the supermoduli space $\mathfrak{M}_g$. The super Mumford isomorphism relates the canonical bundle on $\mathfrak{M}_g$ to the fifth power of the Berezinian of the pushforward of the relative canonical bundle on the universal supercurve. However, in the super case, there is no Hermitian metric given by integration. Instead, the metric is defined in terms of the period map. Furthermore, in contrast to the classical case, the super period map is non-holomorphic and develops a pole along the bad locus. Deligne recently proved that the supermeasure extends smoothly over the bad locus.
In joint work with Ron Donagi, we define a measure on $\mathfrak{M}_{g,0,2r}$, the supermoduli space with Ramond punctures, using the super Mumford isomorphism and super period map, adapted to the case of Ramond punctures. We show that in $\mathfrak{M}_{g,0,2r}$, the analogous bad locus has codimension 2 or higher for $r > 1$, allowing us to extend the measure using a Hartog-like argument.

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Discussion

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Axion Potentials and Moduli Stabilization in Realistic Heterotic M-Theory

A brief review of the observable sector of the B-L MSSM heterotic M-theory is presented. A specific hidden sector involving an anomalous
holomorphic line bundle is analyzed and the associated Green-Schwartz mechanism, axions and

D-term potential are discussed. The complex structure flux, gaugino condensation and string worldsheet superpotentials are analyzed and the associated F-term potential constructed. This is used to analyze the axion potential and vacuum state and then to study the potential for the Kahler moduli. It is shown to admit physically acceptable stable vacuum states, with both AdS and deSitter vacua for varying values of input parameters. The F-term potential energy is proven to satisfy the the Transplanckian Censorship Conjecture.

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Physics and Geometry of Line Bundles over Calabi-Yau Manifolds

The first part of the talk reviews some recent progress in identifying realistic models of particle physics in the context of heterotic strings on Calabi-Yau threefolds with line bundle sums, focusing on the question of deriving the flavour parameters of the Standard Model. The second part discusses the role played by line bundle cohomology in understanding the birational geometry of Calabi-Yau manifolds.

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Discussion