String Data 2024

Abstracts for the parallel session contributed talks

Room 1 (Panasonic hall)

Giorgi Butbaia University of New Hampshire
"Physical Yukawa Couplings"

Calabi--Yau compactifications of the E8×E8 heterotic string provide a promising route to recovering the four-dimensional particle physics described by the Standard Model. While the topology of the Calabi--Yau space determines the overall matter content in the low-energy effective field theory, further details of the compactification geometry are needed to calculate the normalized physical couplings and masses of elementary particles. In this talk, we present numerical computations of physical Yukawa couplings in a number of heterotic models in the standard embedding and demonstrate the existence of natural hierarchies, a coveted feature in string model building.

Michael Lathwood University of New Hampshire
"Machine learning zeta functions"

Zeta functions associated to Calabi-Yau manifolds are number-theoretic objects that have applications to black holes in N=2 supergravity. Using p-adic methods, we compute zeta functions for Calabi-Yau hypersurfaces in toric varieties at many different points in moduli space for a fixed prime. Then, by training the transformer Int2Int, we extend the results to points in moduli space where such a calculation would be currently intractable without machine learning. We comment on the physical implications of our calculations at special points in moduli space, e.g. the conifold point.

Andreas Schachner LMU Munich & Cornell University

"The DNA of Calabi-Yau hypersurfaces"

In this talk, I present an implementation of Genetic Algorithms for triangulations of four-dimensional reflexive polytopes which induce Calabi-Yau threefold hypersurfaces via Batryev's construction. I demonstrate that such algorithms efficiently optimise physical observables such as axion-photon couplings in string compactifications. For our implementation, we choose a parametrisation of triangulations that yields homotopy inequivalent Calabi-Yau threefolds by extending fine, regular triangulations of two-faces, thereby eliminating exponentially large redundancies when mapping polytope triangulations to Calabi-Yau hypersurfaces. In particular, I discuss how this encoding renders the entire Kreuzer-Skarke list amenable to a variety of optimisation strategies, including but not limited to Genetic Algorithms.

Elli Heyes Imperial College London

"Numerically Learning G2 Geometry"

Compactification of 11-dimensional M-theory on G2 manifolds yields a 4-dimensional effective field theory with N=1 supersymmetry. G2 manifolds are therefore the analog of Calabi-Yau (CY) threefolds in 10-dimensional superstring theory. Since 2017 machine-learning techniques have been applied extensively to study CY manifolds but until 2024 no similar work had been carried out on G2 manifolds. We first show how topological properties of these manifolds can be learnt using simple neural networks. We then discuss how one may try to learn Ricci-flat holonomy G2 metrics with machine-learning.

Yidi Qi Northeastern University

"Harmonic 1-forms on real loci of Calabi-Yau manifolds"

We numerically study whether there exist nowhere vanishing harmonic 1-forms on the real locus of some carefully constructed examples of Calabi-Yau manifolds, which would then give rise to potentially new examples of G2-manifolds and an explicit description of their metrics. We do this in two steps: first, we use a neural network to compute an approximate Calabi-Yau metric on each manifold. Second, we use another neural network to compute an approximately harmonic 1-

form with respect to the approximate metric, and then inspect the found solution. Based on work with Rodrigo Barbosa, Michael R. Douglas and Daniel Platt.

Lucas Tsun Yin, Leung University of Oxford

"Fermion Masses and Mixings in String-inspired Models"

We study a class of supersymmetric Froggatt-Nielsen (FN) models with multiple U(1) symmetries and Standard Model (SM) singlets inspired by heterotic string compactifications on Calabi-Yau threefolds. The string-theoretic origin imposes a particular charge pattern on the SM fields and FN singlets. In this talk, I will discuss how by employing genetic algorithms we can identify charge assignments and singlet VEVs that replicate the observed mass and mixing hierarchies in the quark sector, and thereby giving a bottom-up approach that complements top-down string constructions.

Room 2 (Y206)

Muyang Liu University of Southern Denmark

"Unveiling Patterns of Magnetic Quiver"

Magnetic quivers offer a powerful framework for investigating the Higgs branch of supersymmetric gauge theories across dimensions d=3,4,5, and 6, where the processes of fission and decay acted on quivers encode the Higgsing in the underlying theory. In this talk, I will first present a brute-force scanning approach, enhanced by data analysis and machine learning, to systematically explore quiver architecture. Given the complexity of colored quivers with large vertex counts, the facilitation of machine learning methods occurs naturally to uncover patterns and predict Hasse diagram pathways, automating the study of complex quiver structures.

Supragyan Priyadarshinee IISER MOHALI

"Quasi-Normal modes of Dyonic Hairy Black hole and its dynamics"

We explore the dynamics of the massless scalar field in the context of hairy black holes within the Einstein-Maxwell-scalar gravity system. Utilizing both the series solution and shooting methods, we numerically compute the corresponding quasinormal modes (QNMs) across various black hole parameters. Notably, the values obtained from these two methods exhibit robust agreement. The consistently negative imaginary part of the QNM underscores the stability of the massless scalar field in the backdrop of the black hole. Our investigation reveals that both the decay and oscillatory modes of the scalar field perturbation exhibit a linear increase with the horizon radius, particularly notable for large black holes. We conduct a comprehensive analysis of QNMs across diverse black hole parameters, encompassing the electric charge, magnetic charge, horizon radius, and the hairy parameter. Moreover, we extend our scrutiny to the QNM behavior near the small/large black hole phase transition. Intriguingly, we discern distinct characteristics in the nature of QNMs between the large and small black hole phases, indicating the potential of QNMs as a probing tool for black hole phase transitions.

Pritam Nanda Indian Institutes of Science Education and Research, Mohali
"Supertranslation symmetry of isolated horizon"

Akshunna S. Dogra Imperial College London
"Many-fold Learning"

We showcase a dynamical perspective on ML optimization that characterises features observed enroute to convergence of models to solutions across a variety of architectures and problems. The framework is built on top of techniques prevalent in mathematical physics and we showcase how the shared features can be advantageously adapted to analyse data generated in experiments investigating physics beyond the Standard Model, such as SHAPER (arXiv:2302.12266).

Yongchao, Lu KIAS
"S Class Tropical Dataism: Classification and RG flow with eight supercharges"

We will present various methods and tools for the classification of 4d N=2 SCFTs of class S in type A , as well as 5d N=1 SCFTs derived from five-brane webs, along with the RG flows connecting them. Along the way, we will explore various features and patterns in the dataset of these fixed points and RG flows.

Shoji Toyota　　Kyushu University
"Simulation-based Inference for Time Series"

Simulation-based inference (SBI) is a method for estimating parameters in simulators without specific likelihoods. The existing SBI methods are known to be poorly suited for time-series simulations. In this talk, I will introduce our recent work on effectively scaling simulation-based inference to handle time-series simulations.

Room3 (Y306)

Yanick Thurn　　JMU Würzburg
"Predicting trainability of deep neural networks using reconstruction entropy"

An important challenge in machine learning is to predict the initial conditions under which a given neural network will be trainable. We present a method for predicting the trainable regime in parameter space for deep feedforward neural networks, based on reconstructing the input from subsequent activation layers via a cascade of single-layer auxiliary networks. For both the MNIST and CIFAR10 datasets, we show that a single epoch of training of the shallow cascade networks is sufficient to predict the trainability of the deep feedforward network, thereby providing a significant reduction in overall training time.

Marco Alberto Javarone　　University of Bari (Italy), Dutch Institute for Emergent Phenomena (Netherlands), Cryptonary Research Lab
"Deep Structures in Holographic Screens"

In this talk, I introduce an Ising-like model designed to explore the holographic formation of wormholes and demonstrate that its complexity aligns with the Complexity equals Volume conjecture. This approach paves the way for the use of neural networks by creating a bridge between black hole dynamics and machine learning through the holographic screen within the AdS/CFT framework. I illustrate how this model could be used to develop toy systems that simulate the evolution of black holes and uncover the underlying complexities of their formation and growth. This investigation not only sheds light on the theoretical aspects of black hole complexity but also opens potential avenues for integrating machine learning methodologies with insights from String Theory.

Damian Mayorga Pena IST University of Lisbon

"Classical integrablilty of models with cosmological constant: Analytic and ML insights"

We explore the integrability of two-dimensional models derived from the dimensional reduction of four-dimensional theories, which describe the coupling of Maxwell fields and neutral scalars to gravity, including the presence of a potential for the neutral scalar fields (or a cosmological constant). When this potential is absent, the system's integrability is ensured by the existence of a Breitenlohner-Maison (BM) linear system. In this talk, we focus on a solution subspace for models with a scalar potential mainly from a 1D perspective, where the Liouville integrability is described using Lax pair matrices and conserved currents. For these one-dimensional models, we apply various machine learning strategies aimed at predicting such Lax pair matrices and conserved currents, comparing our findings with our analytical results. Finally, we discuss the broader implications of these machine learning approaches in identifying integrable structures in general one-dimensional classical systems. Work in collaboration with G. Cardoso and S. Nampuri.

Satsuki Nishimura Kyushu University

"Reinforcement learning-based statistical search strategy for an axion model from flavor"

We propose a reinforcement learning-based search strategy to explore new physics beyond the Standard Model. As a example, we focus on a minimal axion model with a global U(1) flavor symmetry. Agents of the learning succeed in finding U(1) charge assignments of quarks and leptons solving the flavor and cosmological puzzles, and we discuss the sensitivity of future experiments for the detection of an axion. Thus, the efficient parameter search based on the reinforcement learning enables us to perform a statistical analysis of the vast parameter space associated with the axion model from flavor. This talk based on arXiv:2409.10023.

Mathis Gerdes University of Amsterdam

“Physics informed generative models”

Generative models, and in particular diffusion models, have recently shown great success in learning high dimensional distributions. We have explored how physics, and in particular RG, can inform the design space of diffusion models.

James, Brister Sichuan University

“A dataset for R-symmetric Wess-Zumino models and symmetry breaking”

Wess-Zumino type supersymmetric models (with only chiral superfields) often appear as low-energy limits of stringy models. We are investigating under what circumstances such models generically exhibit the spontaneous breaking of supersymmetry (as well as additional “R” symmetries) required to yield realistic phenomenology. As part of this project, we constructed a dataset of all generic Wess-Zumino models with 6 or fewer superfields and their symmetry-breaking properties. We discuss some of the difficulties in acheiving this through “brute force”, and the potential for the application of machine learning techniques – both in constructing larger data sets, and in analyzing them.