Title and Abstract

8 月 18 日

4：Geometry(5people):

Huijun Fan, Peking University

Title: Quantization of Landau-Ginzburg models

Abstract: Landau-Ginzburg (LG) models are natural objects appearing in the study of mirror symmetry. For instance, the mirror pair of a projective space is the LG model given by Laurent polynomials. It is conjectured in physics that the topological field theory (TFT) of a projective space is equivalent to the TFT of the corresponding LG model. There is also a famous LG/CY correspondence conjecture saying that the Gromov-Witten theory of a Calabi-Yau hypersurface is equivalent to the quantum singularity (FJRW) theory. In this report, I will first focus on the geometry of LG models, review the present research of quantization theory and propose some related questions.

Haizhong Li, Tsinghua University

Title: Hyperbolic summation and hyperbolic convex geometry

Abstract: The convex geometry in Euclidean space is based on the Minkowski summation of two sets. It originated from H. Brunn's thesis in 1887 and H. Minkowski's paper in 1903. In this talk, we introduce a summation for two sets in hyperbolic space, and we call it the hyperbolic summation. We develop a hyperbolic convex geometry by use of our hyperbolic summation. This is joint work with Dr Botong Xu.

Yunhui Wu, Tsinghua University

Title: Prime geodesic theorem and closed geodesics for large genus

Abstract: In this work, we study the Prime Geodesic Theorem for random hyperbolic surfaces. As an application, we show that as the genus g goes to infinity, on a generic hyperbolic surface in the moduli space of Riemann surfaces of genus g, most closed geodesics of length significantly less than $\sqrt{g}$ are simple and non-separating, and most closed geodesics of length significantly greater than $\sqrt{g}$ are non-simple, confirming a conjecture of Lipnowski-Wright. This is a joint work with Yuhao Xue.

Jixiang Fu, Fudan University

Title: Some Progress in Complex Geometry

Abstract: This report will present some advances we have made in the field of complex geometry research, including solutions to the Strominger system, the existence of balanced metrics, and form-type complex Monge-Ampère equations.

Dawei Chen(online), Boston University

Title: Volumes of Moduli Spaces of Differentials

Abstract: A holomorphic differential on a Riemann surface defines a flat metric with cone points at its zeros, such that the underlying surface can be realized as a polygon whose edges are pairwise identified through translations. Varying the shape of such polygons by affine transformations induces a $GL(2,R)$-action on the moduli space of holomorphic differentials, which preserves the zero orders of differentials and thus acts on each stratum of holomorphic differentials with a given type of zero orders. A number of important invariants have been studied extensively for understanding the geometry and dynamics of strata of differentials as well as the $GL(2,R)$-orbit

closures. In this talk, I'll introduce some recent advances in this field, with a focus on computing the volumes of strata of differentials.

2：Algebraic Geometry(5people)

Xiaotao Sun, Tianjin University

Title: Frobenius and vector bundles

Abstract: Let X be a smooth projective variety and $F:X\to X$ be the absolute Frobenius morphism.

It is a natural question to studay the behavior of semi-stable bundles under the functors F^* and F_*.

In this talk, I will review the results and its applications we obtained about this question.

Yu Qiu, Tsinghua University

Title: On moduli spaces of quadratic differentials

Abstract: We first review recent developments on categorification of strata of moduli spaces of quadratic differentials. More precisely, each stratum can be realized by the space of stability conditions of some (not unique) Fukaya-type triangulated category. We further discuss compactification of moduli spaces via categories. Finally, we show that the fundamental group of a stratum with simple zeros equals the kernel of the Abel-Jacobi map.

Jian Zhou, Tsinghua University

Title. Enumerative geometry, statistical physics, and quantum mechanics

Abstract. Enumerative algebraic goemetry is a classical branch of algebraic geometry, we will discuss its modern developments including Gromov-Witten theory via its connections to matrix models and integrable hierachies.. Ideas from statistical physics including Landau-Gingzburg paradigm of phase transitions, Wilson's thoery space and renormalization, and the notion of emergence will play an important role.

We will also discuss the applications of ideas from quantum mechanics, and present a connection to confluence diagram of hypergeometric functions and Askey scheme of hypergeometric orthogonal polynomials. If time allows we will also discuss the connection to fractional quantum Hall effects.

Jie Liu, Chinese Academy of Sciences

Title: Symplectic singularities and the Ginzburg-Kazhdan conjecture

Abstract: Symplectic singularities, introduced by Beauville in 1999, are local singular analogues of holomorphic symplectic manifolds. In 2018, Ginzburg and Kazhdan conjectured that the affine closure of the cotangent bundle of a basic affine space has symplectic singularities. In this talk, I will explain a birational geometry perspective on this conjecture, which extends our approach to arbitrary quasi-affine horospherical spaces. This work is joint with Baohua Fu.

Wenhao Ou, Chinese Academy of Sciences

Title: Rational curves in compact Kaehler manifolds

Abstract: In complex geometry, it is a classic topic to study the existence of rational curves. In 1979, Mori's groundbreaking work proved a criterion for the existence of rational curves in complex projective manifolds. This also led to the theory of Minimal Model Programs. Since Mori's method relies on the algebraicity of projective manifolds, people have few methods to find rational curves in more general complex manifolds, for example in compact Kaehler manifolds. In a recent work, we prove a characterization of uniruled compact Kaehler manifolds. As a result, Mori's theorem can also be extended to general compact Kaehler manifolds.

8月19日：

11 ： Operations Research, Optimization, and Control Theory(4people)

Jiashuo Jiang，The Hong Kong University of Science and Technology

Title: Achieving instance-dependent Sample Complexity for Constrained Markov Decision Process

Abstract: We consider the reinforcement learning problem for the constrained Markov decision process（CMDP）, which plays a central role in satisfying safety or resource constraints in sequential learning and decision-making. In this problem, we are given finite resources and a MDP with unknown transition probabilities. At each stage, we take an action, collecting a reward and consuming some resources, all assumed to be unknown and need to be learned over time. In this work, we take the first step towards deriving optimal problem-dependent guarantees for

the CMDP problems. Our sample complexity bound improves upon the worst-case sample complexity for CMDP problems established in the previous literature, in terms of the dependency on the accuracy level ϵ. To achieve this advance, we develop a new framework for analyzing CMDP problems. To be specific, our algorithm operates in the primal space and we resolve the primal LP for the CMDP problem at each period in an online manner, with adaptive remaining resource capacities. The key elements of our algorithm are: i) a characterization of the instance hardness via LP basis, ii) an eliminating procedure that identifies one optimal basis of the primal LP, and; iii) a resolving procedure that is adaptive to the remaining resources and sticks to the characterized optimal basis. This is based on the joint work with Prof. Yinyu Ye.

Zizhuo Wang, The Chinese University of Hong Kong, Shenzhen

Title: Infrequent Resolving Algorithm for Online Linear Programming

Abstract: Online linear programming (OLP) has gained attention from both researchers and practitioners due to its

extensive applications, such as online auction, network revenue management and advertising. Existing algorithms for OLP can be categorized into two types, LP-based algorithms and LP-free algorithms. The former one typically guarantees better performance, even offering a constant regret, but requires solving a large number of LPs, which could be computationally expensive. In contrast, LP-free algorithm only requires a few first-order computations but induces a worse performance, lacking a constant regret bound. In this work, we bridge the gap between these two extremes by proposing an algorithm that achieves a constant regret while solving LPs only O(log log T) times over the time horizon T. Moreover, we demonstrate the algorithm can guarantee an O(T^{(1/2+ϵ)^(M−1)}) regret by solving LPs only M times. Furthermore, when the arrival probabilities are known at the beginning, our algorithm can also guarantee a constant regret by solving LPs O(log log T) times, and guarantee an O(T^{(1/2+ϵ)^(M)}) regret by solving LPs only M times. In addition, we revisit several resolving schedules (e. g., periodic schedule, midpoint schedule and hyper-exponential schedule) in the literature of network revenue management, prove the constant bound under these schedules, and provide corresponding modified schedules to fit the OLP problem. Lastly, numerical experiments are conducted to demonstrate the efficiency of the proposed algorithm.

Dongdong Ge，Shanghai Jiao Tong University

Title: History and Development Trends of Optimization Algorithms and Software

Abstract: This report provides an introductory summary of the concepts, algorithms, and historical development of mathematical programming, as well as an overview and analysis of trends in mathematical optimization software. In particular, it highlights recent progress in GPU-based first-order algorithms for solving large-scale optimization models, and explores their potential applications in traditional industries and emerging fields such as quantum computing.

Chao Ding，Chinese Academy of Sciences

Title: Adaptive Regularized Newton-CG for Nonconvex Optimization: Optimal Global Complexity and Quadratic Local Convergence

Abstract: Finding an ϵ-stationary point of a nonconvex function with a Lipschitz continuous Hessian is a central problem in optimization. However, existing regularized Newton methods face a fundamental trade-off: methods achieving optimal $O(\epsilon^{-\frac{3}{2}})$ global complexity typically exhibit only linear local convergence. In contrast, those with quadratic local rates often have suboptimal global performance. To bridge this long-standing gap, in this talk, we propose a new class of regularizers constructed using the conjugate gradient approach with a negative curvature monitor to solve the regularized Newton equation. The proposed algorithm is adaptive, requiring no prior knowledge of the Hessian Lipschitz constant, and achieves a global complexity of $O(\epsilon^{-\frac{3}{2}})$ in terms of the second-order oracle calls, and $\tilde O(\epsilon^{-\frac{7}{4}})$ for Hessian-vector products, respectively. When the iterates converge to a point where the Hessian is positive definite, the method exhibits quadratic local convergence.

Preliminary numerical results, including training the physics-informed neural networks, illustrate the competitiveness of our algorithm.

1：Number Theory(5people)

Yichao Tian, Chinese Academy of Sciences

Title: On some recent progress on p-adic comparison theorems

Abstract: Comparison theorems between different p-adic cohomology theories are central topics in p-adic Hodge theory. Recently, Bhatt—Scholze's prismatic cohomology theory provides a new framework to understand various p-adic cohomology theories. In this talk, I will give a review of some recent progress of p-adic comparison via prismatic approach. A new result is a prismatic-etale comparison theorem for semi-stable local systems, which generalizes Guo—Reinecke's result in the crystalline case.

Xu Shen, Chinese Academy of Sciences

Title: p-adic locally symmetric varieties

Abstract: We will discuss the theory of p-adic uniformization of Shimura varieties and some applications to the Langlands program.

Peng Shan, Tsinghua University

Title: Bridging affine vertex algebras and affine Springer fibres

Abstract: I would like to explain a program which aims to build relationships between affine Springer theory and representations of simple affine vertex algebras. We will discuss some explicit correspondence for admissible levels, and formulate some new conjectures about representations of simple affine vertex algebras at integer nonadmissible levels and their associated varieties. This is based on joint work with Dan Xie, Wenbin Yan and Qixian Zhao.

Penghui Li, Tsinghua University

Title: Hecke categories and their (co)center

Abstract: Hecke categories are the geometrization/categorification of Hecke algebras and play a key role in geometric representation theory. We study the (co)center of (affine) Hecke category. As an application, we proof the two dimensional generalization of Chavelley restriction theorem for reductive algebraic group. This talk is based on joint work with Fragile Dragos, Sam Gunningham, Quoc P. Ho, David Nadler, and Zhiwei Yun.

Hourong Qin, Nanjing University

Title: A Connection between the BSD conjecture and the Birch-Tate conjecture

Abstract: We demonstrate an intrinsic link between the Birch and Swinnerton-Dyer (BSD) conjecture for congruent elliptic curves and the Birch-Tate conjecture. This discovery emerges from two key contributions in our research: (1) a formula for the value of the L-function at s=1 for congruent elliptic curves, achieved through our development of a weight 3/2 Shimura lift method; and (2) an 8-rank formula for the Milnor group of the ring of algebraic integers in a quadratic field.

5：Topology and Combinatorics(2people)

Jianfeng Lin, Tsinghua University

Title: On mapping class groups of 4-manifolds

Abstract: In this talk, I will discuss some recent results regarding mapping class groups of 4-manifold, using invariants from configuration spaces. In particular, I will sketch a proof that the mapping class group of a surface cross the 2-sphere is not finitely generated. I will also talk about some connections with Gabai's lightbulb theorem. And I will discuss some applications in symplectic topology (nonisotopic symplectic forms on 4-manifolds). This talk is based on a joint work with Boyu Zhang, Yi Xie and a joint work with Weiwei Wu.

Jie Wu, Beijing Institute of Mathematical Sciences and Applications

Title: Simplicial topology, braids, knots, and GLMY theory

Abstract: Simplicial technologies play a fundamental role for establishing interdiscinary research between algebraic topology and other areas of mathematics and sciences, from simplicial complex modeling in sciences to simplicial homotopy theory approaches to higher categories. In this talk, we will give an introduction to our works on the structures of higher homotopy groups via simplicial and combinatorial techniques that gave rise to the fundamental connections between homotopy groups and the theory of braids, as well as the fundamental connections between the

homotopy theory of loop spaces and modular representation theory of symmetric groups. Furthermore, we will give a report on our work in GLMY theory and its applications in molecular biology, complex diseases, materials and complex networks.

8 月 20 日：

10：Scientific Computing and Quantum Computing(3people)

Jinpeng Liu，Tsinghua University

Title: Linear Combination of Hamiltonian Simulation for Non-unitary Dynamics: Theorems and Applications

Abstract: Fault-tolerant quantum computers are expected to excel in simulating unitary dynamics, such as the dynamics of a quantum state under a Hamiltonian. Most applications in scientific and engineering computations involve non-unitary dynamics. First, we propose a simple method for simulating a general class of non-unitary dynamics as a linear combination of Hamiltonian simulation (LCHS) problems. The LCHS method can achieve optimal cost in terms of state preparation. Second, we generalize the LCHS formula to simulate time-evolution operators in infinite-dimensional spaces, including scenarios involving

unbounded operators. We demonstrate the applicability of LCHS to a wide range of non-Hermitian dynamics, including linear parabolic PDEs and open quantum system dynamics. Our analysis provides insights into simulating general linear dynamics using a finite number of quantum dynamics and includes cost estimates for the corresponding quantum algorithms.

References:

1. Linear combination of Hamiltonian simulation for non-unitary dynamics with optimal state preparation cost. Physical Review Letters, 131(15):150603 (2023).

2. Infinite-dimensional Extension of the Linear Combination of Hamiltonian Simulation: Theorems and Applications. arXiv:2502.19688

Tiexiang Li，Southeast University

Title: Metric-Preserving Computational Geometry and Its Applications

Abstract: The remarkable achievements in computational conformal geometry have profoundly demonstrated the fundamental importance of preserving geometric attributes

in scientific computing. Building upon this foundation, we transcend the limitations of traditional computational conformal geometry (angle-preserving transformations) by proposing the innovative paradigm of Metric-Preserving Computational Geometry. This groundbreaking framework establishes a comprehensive theoretical system and methodological architecture for rigorously conserving multiple geometric measures including - but not limited to - area, volume and mass. In this work, in light of the Dirichlet energy, we define the n-dimensional volumetric stretch energies (n-VSEs) on an n-dimensional manifold $\mathcal{M}$ for both continuous and discrete cases, and propose an effective n-VSE minimization (n-VSEM) algorithm for the computation of volume-/mass-preserving parameterizations between $\mathcal{M}$ and a unit n-ball $\mathbb{B}^n$. Furthermore, we demonstrate the remarkable efficacy of our metric-preserving computational geometry algorithms in both brain tumor imaging and histological image processing.

Zhengwei Liu，Tsinghua University

Title: Quantum Advantages and Classical Simulations

Abstract: We establish Quon Classical Simulation (QCS), answering a long standing open question on unifying efficient classical simulations of both Clifford and Matchgates quantum circuits. QCS unifies various classical simulation methods and provides new insights to explore quantum advantage.
Inspired by it, we design a new quantum algorithm to solve binary polynomial equations. It provides a new paradigm to solve NP hard mathematical problems, such as constructing new tensor categories.

9：Numerical Analysis and Image Processing(3people)

Lingyun Qiu，Tsinghua University

Title: Sediment Concentration Estimation via Multiscale Inverse Problem and Stochastic Homogenization

Abstract: In this work, we present a novel approach for sediment concentration measurement in water flow, modeled as a multiscale inverse medium problem. To address the multiscale nature of the sediment distribution, we treat it as an inhomogeneous random field and use the homogenization theory in deriving the effective medium model. The inverse problem is formulated as the

reconstruction of the effective medium model, specifically, the sediment concentration, from partial boundary measurements. Additionally, we develop numerical algorithms to improve the efficiency and accuracy of solving this inverse problem. Our numerical experiments demonstrate the effectiveness of the proposed model and methods in producing accurate sediment concentration estimates, offering new insights into sediment measurement in complex environments.

Yi Zhu，Tsinghua University

Title: A reinforcement-learning-based method for solving high-dimensional integro-differential equations

Abstract: High-dimensional partial integro-differential equations often appear in finance and other real applications. Traditional method like finite difference and finite element methods suffer from the curse of dimensionality. In this talk, I shall introduce a deep learning framework, which we proposed recently, for solving high-dimensional partial integro-differential equations based on the temporal difference learning. We introduce a set of Levy processes and construct a corresponding reinforcement learning model. To simulate the entire process, we use deep neural networks to represent the solutions and non-local terms of the equations. Subsequently, we train the networks using the temporal difference error, termination condition, and properties of the non-local terms as the loss function. Our method demonstrates the advantages of low computational cost and robustness, making it well-suited for addressing problems with different forms and intensities of jumps. Rigorous error estimate are also provided to guarantee the validity of the proposed method. I will also introduce extensions of this method to stochastic controls and multi-agent relative investment games.

Jun Wang，Tsinghua University

Title: Recent advances of integral equation methods

Abstract: In this talk, we present recent development of integral equation methods, focusing on two classes of problems: systems of two point boundary value problems and parabolic PDEs in moving geometry. The former has a variety of applications ranging from the computation of dynamical systems to optimal control problems, while the

latter plays an essential role in the numerical simulation of physical and engineering problems such as crystal growth, diffusion MRI, and complex fluids. In both cases, we demonstrate by an abundance of numerical examples that by choosing a proper integral formulation, and incorporating suitable fast algorithms (such as fast direct solvers and the newly developed adaptive fast Gauss transform), we obtain numerical methods that are fast, adaptive and accurate (achieving arbitrary order of convergence).

Artificial Intelligence and Algorithms(2people)

Min Zhang, Zhejiang University

Title: Geometry-inspired AI Algorithms and Applications

Abstract: My research focus on the burgeoning field of geometry-inspired artificial intelligence (AI), where I investigate novel algorithms fundamentally motivated by geometric principles. This work delves into the theoretical underpinnings of such approaches, examining how concepts from differential geometry, topology, graph theory, and computational geometry enhance core AI capabilities, including robustness, efficiency, and interpretability. The

contribution involves synergistically integrating geometric frameworks with cutting-edge AI architectures such as diffusion models, generative adversarial networks, and graph neural networks to develop new algorithms. These methodologies have been successfully deployed across diverse domains, including computer graphics and vision, medical image processing, and protein design, achieving quantifiable gains across critical performance.

Lin Gan，Tsinghua University

Title: Extreme Scale Earthquake Simulation with Crossing Multi-faults and Topograph

Abstract: This talk introduces our latest efforts on porting the FD-based earthquake simulation projects onto the Sunway New supercomputer, one of the largest supercomputers in China. Sophisticated HPC solutions are proposed to fully exploit the hardware performance potential.

8 月 21 日

7：Probability(4 people)

Zhan Shi，Chinese Academy of Sciences

Title: The effective resistance problem of the critical series-parallel graph

Abstract: The asymptotic behavior of the effective resistance of the critical random series-parallel graph was predicted by Hambly and Jordan (2004). The conjecture, simple and innocent-looking, was strengthened by Addario-Berry et al. (2020), and furthermore by Derrida (2022). I am going to make some elementary discussions on these conjectures. Joint work with Xinxing Chen (Shanghai) and Thomas Duquesne (Paris).

Fengyu Wang，Tianjin University

Title: Spectral Representations on Wasserstein Limits of Empirical Measures on Manifolds

Abstract: Sharp convergence rates in Wasserstein distance are derived for empirical measures of diffusion processes on Riemannian manifolds, the renormalization limits are explicitly formulated by using the volume of the manifold as well as eigenvalues and eigenfunctions of the associated elliptic operator.

Hao Wu，Tsinghua University

Title: Connection probabilities for loop O(n) models and BPZ equations

Abstract: Critical loop O(n) models are conjectured to be conformally invariant in the scaling limit. In this talk, we focus on connection probabilities for loop O(n) models in polygons. Such probabilities can be predicted using two families of solutions to Belavin-Polyakov-Zamolodchikov

(BPZ) equations: Coulomb gas integrals and SLE pure partition functions. The conjecture is proved to be true for the critical Ising model, FK-Ising model, percolation, and uniform spanning tree.

Jianping Jiang，Tsinghua University

Title: Percolation of both signs in a triangular-type 3D Ising model above T_c

Abstract: Let $\mathbb{T}$ be the two-dimensional triangular lattice, and $\mathbb{Z}$ the one-dimensional integer lattice. Let $\mathbb{T} \times \mathbb{Z}$ denote the Cartesian product graph. Consider the Ising model defined on this graph with inverse temperature β and external field h, and let β_c be the critical inverse temperature when $h=0$. We prove that for each $\beta \in [0,\beta_c)$, there exists $h_c(\beta)>0$ such that both a unique infinite +cluster and a unique infinite -cluster coexist whenever $|h|<h_c(\beta)$. The same coexistence result also holds for the three-dimensional triangular lattice. Based on joint work with Sike Lang.

8: Statistics(3people)

Rongling Wu, Beijing Institute of Mathematical Sciences and Applications

Title: The graph representation theory of statistics

Abstract: We live in an era of big data, where everyone can access a steam of data as scientific treasures at their fingertips. Traditional statistics is powerful for analyzing independent and identically distributed data at a limited dimension, but it can hardly meet the requirement of big data analysis. Big data often emerge as dynamic graphs or networks, in which variables (encoded as nodes) and their interrelationships (encoded as edges) act together as a cohesive whole to determine internal workings of networks. In this talk, I will be presenting a new norm of statistical thinking, which combines evolutionary game theory,

ecological niche theory, topological theory, and graph theory through quasi-dynamic nonlinear modeling, to create a graph representation theory of statistics. This theory could leverage statistics to better predict the future and transform big data into practical values.

Zhigang Yao，National University of Singapore

Title: Interaction of Statistics and Geometry: A New Landscape for Data Science

Abstract: While classical statistics primarily focuses on observations as real numbers or elements of real vector spaces, contemporary statistical challenges often involve more complex data types. These data are represented in spaces that, although not strictly Euclidean vector spaces, possess inherent geometric structures. The community exploring the interaction between statistics and geometry is expanding in both numbers and scope. The concept of manifold fitting traces back to H. Whitney's work in the early 1930s. The resolution of the Whitney extension problem has yielded new insights into data interpolation and inspired the formulation of the Geometric Whitney Problems.

Specifically, given a set, we inquire: when can we construct a smooth d-dimensional sub-manifold to approximate the set, and how effectively can we estimate it in terms of distance and smoothness? In this talk, I will explore the manifold fitting problem, highlighting its modern insights and implications. Although various mathematical approaches have been proposed, many rely on restrictive assumptions, complicating the development of efficient and practical algorithms. As the manifold hypothesis-exploring non-Euclidean structures-remains a cornerstone of data science, further exploration of the manifold fitting problem is

essential within the contemporary data science community. This discussion will be informed by recent work by Yao, Yau, and other coauthors, alongside ongoing research.

Weijie Su，University of Pennsylvania

Title: A Statistical Framework of Watermarks for Large Language Models: Theory, Applications, and Future Opportunities

Abstract: Watermarking, the embedding of subtle statistical

signals into text generated by large language models (LLMs), has become a principled approach to distinguishing synthetic text from human-written content. In this talk, we will provide a statistical overview of watermarking techniques for LLMs, focusing on their theoretical foundations and practical applications. First, we introduce a general framework for evaluating the statistical efficiency of watermarks, which enables the design of optimal detection rules with rigorous control of false positive and false negative rates. Building on this framework, we address the challenge of robust detection under extensive human edits, proposing a truncated goodness-of-fit approach that adaptively achieves optimal detection power in mixture-model settings, outperforming conventional sum-based methods. We then consider practical scenarios involving mixed-source text, blending human-written and watermarked content, and demonstrate how to estimate the proportion of watermarked text for attribution purposes. Empirical results across diverse scenarios validate the effectiveness of these methods. We conclude the talk by exploring several future directions and open questions in watermarking research.

3: Mathematical Physics(3people)

Yu Deng, University of Chicago

Title: The Hilbert Sixth Problem: particle and waves

Abstract: A major part of Hilbert's Sixth Problem asks for the mathematical justification of the passage from atomistic interactions to the laws of motion of continuum. In the particle setting, this corresponds to Hi;bert's program of going from Newtonian particle dynamics to fluid equations via Boltzmann's equation. In the wave setting, one starts from nonlinear dispersive equations and aims at deriving the wave kinetic equation, i.e. wave analog of Boltzmann's equation.

In this talk I will present recent works, joint with Zaher Hani and Xiao Ma, that lead to the resolution of both problems, starting from hard sphere dynamics for particles, and the cubic NLS equation for waves. The two proofs follow the similar framework but have very different features.

Ling-Yan Hung, Tsinghua University

Title: A 2D CFT Factory : Critical lattice models from competing anyon condensation in SymTFT

Abstract: In this talk, we introduce a ``CFT factory" : a novel algorithm of methodically generating 2D lattice models that would flow to 2D conformal fixed points in the infrared. These 2D models are realised by giving critical boundary conditions to 3D topological orders (symTOs/symTFTs) described by string-net models, often called the strange correlators. We engineer these critical boundary conditions by introducing a commensurate amount of non-commuting anyon condensates. The non-invertible symmetries preserved at the critical point can be controlled by studying a novel ``refined condensation tree". Our structured method generates an infinite family of critical lattice models, including the A-series minimal models, and uncovers previously unknown critical points. Notably, we find at least three novel critical points ($c \approx 1.3$, 1.8, and 2.5 respectively) preserving the Haagerup symmetries, in addition to recovering previously reported ones. The condensation tree, together with a generalised Kramers-Wannier duality, predicts precisely large swathes of phase boundaries, fixes almost completely the global phase diagram, and sieves out second order phase transitions.

This is not only illustrated in well-known examples (such as the 8-vertex model related to the $\mathbf{A}_5$ category) but also further verified with precision numerics, using our improved (non-invertible) symmetry-preserving tensor-network RG, in novel examples involving the Haagerup symmetries. We show that critical couplings can be precisely encoded in the categorical data (Frobenius algebras and quantum dimensions in unitary fusion categories), thus establishing a powerful, systematic route to discovering and potentially classifying new conformal field theories.

Junwu Tu, Shanghai University of Science and Technology

Title: Enumerative invariants from Calabi-Yau categories

Abstract: Since the beginning of Kontsevich's homological mirror symmetry proposal in 1994, he suggested that one should be able to recover the Gromov-Witten invariants from the Fukaya category of a symplectic manifold. In this talk, we shall describe the construction of such type invariants associated with general Calabi-Yau categories, following Costello and Caldararu-T. . These invariants, conjecturally, generalizes simultaneously the Gromov-Witten

invariants, the Fan-Jarvis-Ruan-Witten invariants, and the Saito-Givental invariants.

When applied to the derived category of coherent sheaves of a smooth projective Calabi-Yau, again conjecturally, the resulting invariants should match with the BCOV invariants in string theory. We also survey on recent progresses in this field.

Fluid Mechanics and Solid Mechanics(2people)

Fan Zheng, ICMAT

Title: Finite time singularities for incompressible fluids

Abstract: The question of singularity formation in fluid dynamics remains one of the most challenging open problems in mathematical physics. In this talk, we present new results showing that solutions to 3D hypodissipative Navier-Stokes equations with smooth initial data and an external forcing that is integrable in $C^{1+\epsilon}$ can break down in finite time. The dissipation in the equation amounts to 0.1 orders of derivative, or $(-\Delta)^{0.046}$. Time permitting, I will discuss extensions that allow for more dissipation and rougher forcing.

Weifeng Zhao, University of Science and Technology Beijing

Title: Strictly convex entropy and entropy stable schemes for the reactive Euler equations

Abstract: This talk is concerned with the reactive Euler equations describing inviscid compressible flow with chemical reactions. We point out that for these equations as a hyperbolic system, the classical entropy function associated with the thermodynamic entropy is no longer strictly convex under the equation of estate (EoS) for the ideal gas. Two strategies to address this issue will be presented. The first one is to correct the entropy function. We present a class of strictly convex entropy functions by adding an extra term to the classical one. Such strictly entropy functions can symmetrize both the reactive Euler equations and the reactive Navier-Stokes equations. The second strategy is to modify the EoS. We show that there exists a family of EoS (for the nonideal gas) such that the classical entropy function is strictly convex. Under these new EoS, the reactive Euler equations are proved to satisfy the Conservation-Dissipation Conditions for general hyperbolic relaxation systems, which guarantee the

existence of zero relaxation limit. Furthermore, an elegant eigen-system of the Jacobian matrix is derived for the reactive Euler equations under the proposed EoS. Numerical experiments demonstrate that the proposed EoS can also generate ZND detonations. Finally, we design entropy stable discontinuous Galerkin schemes based on the proposed strictly entropy function, which are validated with several numerical examples.

8 月 22 日：

6：Differential Equations and Dynamical Systems(5people)

Jinxin Xue, Tsinghua University

Title: Singularities in dynamics and geometry

Abstract: Singularities appear in various fields of mathematics. In this talk, we report our study of singularities in dynamics and geometry. There are some common themes in our study of singularities in the two fields, such as the blowup procedure, monotonicity, hyperbolicity, etc.

In dynamical systems, we focus on the N-body problem. Singularities may be collisions or not. In the former case, blowing up the singularities gives self-similar solutions

called central configurations, in the latter case, the existence of noncolllision singularities has been conjectured by Painleve in 1897, and the program was finally completed by the author.

In geometry, we focus on the mean curvature flows. Again blowing up a singularity gives self-similar solutions called shrinkers. By analyzing the local dynamics of the rescaled mean curvature flow approaching the shrinker, we derive geometric informations of the flow as well as the initial manifold. We shall report our work on avoiding unstable shrinkers, isolatedness of cylindrical singularities, passing through singularities and C2 regularity of singularity sets.

Juncheng Wei, The Chinese University of Hong Kong

Title: A complete solution to Brezis' first open problem

Abstract: In 2023, one year before he died, H. Brezis published a list of more than 30 his ``favorite open problems", which he described as challenges he had ``raised throughout his career and has resisted so far". We provide a complete resolution to the first one--Open Problem 1.1--on Brezis' favorite open problems list: the

existence of solutions to the long-standing Brezis-Nirenberg problem on a three-dimensional ball. Furthermore we establish the existence for the full range of parameters.

Jiangong You, Nankai University

Title：The Cantor Spectrum Problem

Abstract: Quasi-periodic environments are situated between (simple) periodic environments and (complex) random environments. Schrödinger operators with quasi-periodic potentials possess significant quantum physical backgrounds, such as the quantum Hall effect, quasicrystals, and topological insulators. The Cantor spectrum is a spectral phenomenon predominantly observed in quasi-periodic Schrödinger operators and forms the basis for the logic underlying the integer quantum Hall effect. Owing to its profound mathematical richness, the quasi-periodic Schrödinger operator has garnered attention from numerous distinguished mathematicians, including Moser, Sinai, Bourgain, Spencer and Avila. This report aims to present our recent advancements in the study of Cantor spectra, encompassing the Dry Ten Martini problem, robust Cantor spectrum, quantitative global theory, and estimates of

spectral gaps. The findings are based on several recent collaborative efforts with Avila, Ge Lingrui, Leguil, Jitomirskaya, Zhao Zhiyan, and Zhou Qi.

Zhijie Chen, Tsinghua University

Title: Mean field equations and Green functions on torus, and Lame equations

Abstract: I will talk about mean field equations on torus, introduce its deep connections with the Green function on torus and the Lame equation from integrable systems.

Siyuan Ma, Chinese Academy of Sciences

Title: On Kerr stability conjecture

Abstract: I will report my recent progress on the resolution of Kerr stability conjecture in the case of large angular momentum.

9: Numerical A nalysis and Image Processing(2people)

Chenglong Bao，Tsinghua University

Title: A Unified Approach for Data Synthesis in Imaging: Integrating Paired and Unpaired Datasets

Abstract: A significant gap between theory and practice in imaging sciences arises from inaccuracies in mathematical models, including imperfect imaging models and complex noise. Recent advancements have seen deep neural networks directly mapping observed data to clean images using paired training data. While these approaches deliver promising results across various tasks, collecting paired training data remains challenging and resource-intensive in practice. To address this limitation, we propose a unified generative model capable of leveraging both paired and unpaired data during training. Once trained, the model can generate high-quality synthetic data for direct use in downstream tasks. Experimental results on diverse real-world datasets demonstrate the effectiveness of the proposed methods. Finally, I will present recent progress in addressing the preferred orientation problem in cryo-EM, showcasing how these tools contribute to advancing the field.

Chunmei Su，Tsinghua University

Title: Temporal high-order structure-preserving parametric finite element methods for curvature flows

Abstract: The quality of the mesh is crucial for simulating

curvature flows, as standard approaches may fail due to mesh distortion. We first present a series of high-order parametric finite element methods based on the BGN formulation for solving various types of flows involving curves and surfaces. Extensive numerical experiments demonstrate the anticipated high-order accuracy while maintaining favorable mesh quality throughout the evolution process. Secondly, for flows involving multiple geometric structures, such as surface diffusion—which reduces area while preserving volume—we propose a type of structure-preserving method that incorporates two scalar Lagrange multipliers along with two evolution equations related to area and volume, respectively. These schemes effectively preserve the geometric structure at a fully discrete level. Comprehensive numerical experiments illustrate that our methods achieve the desired temporal accuracy, while simultaneously preserving the geometric structure of the surface diffusion.

3：Mathematical Physics(3people)

Xin Sun, Peking University

Title: Application of Liouville quantum gravity to 2D percolation

Abstract: I will use 2D percolation as an example to demonstrate how Liouville quantum gravity (LQG) is used in the recent progress on the exact solvability in 2D statistical physics. Comparing to previous applications of quantum gravity in statistical physics based on the Knitznik-Polyakov-Zamolodchikov (KPZ) relation, the crucial novelty of the recent applications is the interplay between the exact solvability in Liouville conformal field theory and the coupling theory of LQG and SLE.

Conan Nai Chung LEUNG, The Chinese University of Hong Kong

Title: SYZ mirror symmetry

Abstract: Mirror symmetry is a mysterious, yet far reaching, conjectural equivalence between symplectic geometry and complex geometry. SYZ proposal provided a groundbreaking geometric explanation to mirror symmetry. This talk will explain mathematical results on different aspects of geometry arising from SYZ proposal.

Chi-Ming Chang, Tsinghua University

Title: Cohomology Problems from Black Holes

Abstract: I will introduce the supercharge Q-cohomology in holographic quantum field theories. It characterizes the microstates of supersymmetric black holes in dual quantum gravity, and generates many interesting cohomology problems. The talk will take N=4 super-Yang–Mills (SYM) theory as the main example: the existence of supersymmetric black holes in its gravity dual predicts novel cohomology classes and falsifies a longstanding conjecture on a relation between cyclic cohomology and Lie algebra cohomology.