丘成桐数学科学中心
YAU MATHEMATICAL SCIENCES CENTER

清華大學求真书院
Qiuzhen College, Tsinghua University

北京雁栖湖应用数学研究院
YANQI LAKE BEIJING INSTITUTE OF MATHEMATICAL SCIENCES AND APPLICATIONS

中国科学院晨兴数学中心
MORNINGSIDE CENTER OF MATHEMATICS CHINESE ACADEMY OF SCIENCES

数学科学前沿大会
FRONTIERS IN MATHEMATICAL SCIENCE

2022.12.22-29

数学科学年终盛会
END OF THE YEAR GALA FOR MATHEMATICAL SCIENCE

2022.12.24

TSIMF
清华三亚国际数学论坛

受邀参会

北京大學 PEKING UNIVERSITY
東南大學 SOUTHEAST UNIVERSITY
復旦大學 FUDAN UNIVERSITY
上海交通大學 SHANGHAI JIAO TONG UNIVERSITY
武漢大學 WUHAN UNIVERSITY
香港中文大學 The Chinese University of Hong Kong
浙江大學 ZHEJIANG UNIVERSITY
中山大學 SUN YAT-SEN UNIVERSITY
中国科学技术大学 University of Science and Technology of China

丘成桐数学科学中心 YAU MATHEMATICAL SCIENCES CENTER　清华大学 求真书院 Qiuzhen College, Tsinghua University　北京雁栖湖应用数学研究院 YANQI LAKE BEIJING INSTITUTE OF MATHEMATICAL SCIENCES AND APPLICATIONS　中国科学院晨兴数学中心 MORNINGSIDE CENTER OF MATHEMATICS CHINESE ACADEMY OF SCIENCES

数学科学前沿大会

FRONTIERS IN MATHEMATICAL SCIENCE

2022.12.22

TSIMF 清华三亚国际数学论坛 **A211报告厅**

9:00-10:30

开幕式

- 主持人介绍参会嘉宾
- 丘成桐院士致辞
- 海南省领导致辞
- 海南省科技厅领导致辞
- 三亚市领导致辞
- 数学家代表致辞
- 开幕式结束、合影

12:45-14:45

数学科学研究与海南“陆海空”科技产业创新研讨会

- 丘成桐院士致辞
- 海南省崖州湾种子实验室杨帆研究员做学术报告
- 隆平生物吕玉平教授做学术报告
- 北京雁栖湖应用数学研究院PI邬荣领研究员做学术报告
- 中国石油大学（北京）海南研究院院长杨进教授做学术报告
- 南京应用数学中心常务副主任刘继军教授做学术报告
- 海南省航天技术创新中心副主任李晓明研究员做学术报告
- 东南大学丘成桐中心主任助理李铁香教授做学术报告
- 海南省科技厅领导致辞
- 研讨会结束

15:00-18:00

基础数学报告——菲尔兹奖得主报告

2022.12.23, 26-29　学术报告

2022.12.24　数学科学年终盛会暨颁奖大会

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About

Frontiers in Mathematical Science

This conference is aiming to bring experts in pure mathematics and applied math together to share their most recent work. The conference will be held in the Tsinghua-Sanya forum on December 22nd-29th. This is a hybrid conference, although we expect in-person communication during the conference.

Organizing Committee

Shing-Tung Yau	Tsinghua University
Shiu-Yuen Cheng	Tsinghua University
Xuan Gao	TSIMF
Yingying Zhang	Tsinghua University
Yi Li	Southeast University
Mao Sheng	Tsinghua University

Website

http://www.tsimf.cn/meeting/detail?id=301

Timetable

December 22nd, Thursday

Zoom number: 892 226 4912 Password: YMSC

Time	Welcome to Sanya	
9:00–10:30	**Opening Ceremony**	
Lunch		
Chair: Shing-Tung YAU		
15:00–16:00	**Caucher BIRKAR**	Groups of symmetry
Chair: Mao SHENG		
16:00–17:00	**Maxim KONTSEVICH**	Introduction to resurgence
Chair: Senya SHLOSMAN		
17:00-18:00	**Yuval PERES**	From Laplacian growth to competitive erosion
Dinner		
Chair: Yi ZHU		
19:30–20:30	**Paul MILEWSKI**	Mathematics in Internal Waves: mode-2 solitary waves in 3-layer flows

December 23rd, Friday

Section 1

Zoom number: 892 226 4912 Password: YMSC

Time	Pure Mathematics	
Chair: Bowen ZHAO		
08:00-09:00	**Lars ANDERSSON**	Gravitational instantons and special geometry
Chair: Shing-Tung YAU		
09:00-10:00	**Andrei OKOUNKOV**	The beauty of the 3d mirror symmetry
Chair: Mao SHENG		

10:00–11:00	**Yichao TIAN**	On p-adic comparison theorems
Chair: Wei Song		
11:00–12:00	**Hirosi OOGURI**	Symmetry-Resolved Density of States
Lunch		
Chair: Ivan FESENKO		
14:00–15:00	**Mao SHENG**	Torsion property of the zero of a Kodaira-Spencer system
Chair: Si LI		
15:00–16:00	**Fangyang ZHENG**	Hermitian manifolds: when Chern connection is Ambrose-Singer
Chair: Lars ANDERSSON		
16:00–17:00	**Pieter BLUE**	SUSY stability of higher dimensions
Chair: Mao SHENG		
17:00–18:00	**Junyan CAO**	Infinitesimal extension of adjoint forms in Kähler setting and applications
Dinner		
Chair: Mao SHENG		
19:30–20:30	**Heng DU**	A sheaf theoretic approach to overconvergence of étale (ϕ, Γ)-modules
Chair: Lars ANDERSSON		
20:30-21:30	**Mu-Tao WANG**	Angular momentum in general relativity

Section 2

Zoom number: 276 366 7254   Password: YMSC

Time	**Applied Mathematics**	
Chair: Tiexiang LI		
08:00-09:00	**Rengcang LI**	Optimization on Stiefel Manifold and Nonlinear Eigenvalue problem
09:00-10:00		Break
10:00–11:00	**Fan YANG (F)**	Mediation analysis with mediator and outcome missing not at random
11:00–12:00	**Rongling WU**	Growth Network: A Statistical Physics Theory to Wire Up All Growth Genes
Lunch		
Chair: Jijun LIU		
14:00–15:00		Break

15:00–16:00	**Jiaqing YANG**	Numerical reconstruction of locally rough surfaces by a Newton iterative algorithm
16:00–17:00	**Yuewei DAI**	海洋中的神秘乐章-水声隐蔽通信
17:00–18:00	**Linlin ZHONG**	Physics-informed low-temperature plasma simulation and its acceleration technology
Dinner		
Chair: Meng CAO		
19:30–20:30	**Hui YU**	Emergent behaviors of the Justh-Krishnaprasad model with uncertain communications

December 24th, Saturday

Section 1

Zoom number: 892 226 4912 Password: YMSC

Time	**Pure Mathematics**	
Chair: Mao SHENG		
08:00-09:00	**Song SUN**	Geometry of 4 dimensional Calabi-Yau metrics
09:00-10:00	**Xu SHEN**	F-zips with additional structure on splitting models of Shimura varieties
Chair: Kirillov ANATOLI		
10:00–11:00	**Nicolai RESHETIKHIN**	Symmetric spaces and Yang-Mills theory on open-closed surfaces
Chair: Shing-Tung YAU		
11:00–12:00	**Zhouping XIN**	On Entropy Bounded Strong Solutions to The Compressible Navier-Stokes Equations with Far Fields Vacuum
Dinner		

Section 2

Zoom number: 276 366 7254 Password: YMSC

Time	**Applied Mathematics**	
Chair: Wuyue YANG		
08:00-09:00	**Jianqing FAN**	FAST-NN for Big Data Modeling
Chair: Jungong XUE		

09:00-10:00	**Yue QIU**	Low-rank Methods for Bayesian Inverse Problems
Chair: Li WANG		
10:00–11:00	**Liping ZHANG**	Randomized Algorithms for Discrete Ill-Posed Problems
Chair: Fulong LIN		
11:00–12:00	**Luo LUO**	Streaming Algorithms for Matrix Approximation
Dinner		

December 26th, Monday

Section 1

Zoom number: 892 226 4912 Password: YMSC

Time	**Pure Mathematics**	
Chair: Heng DU		
08:00-09:00	**Huajia WANG**	Perturbative causal shadows in AdS/CFT
09:00-10:00	**Weitong WANG**	Introduction to Arithmetic Statistics
10:00–11:00	**Zhangchi CHEN**	Directed harmonic currents near non-hyperbolic linearizable singularities
11:00–12:00	**Ya DENG**	How fundamental groups of algebraic varieties determine their hyperbolicity
Lunch		
Chair: Dongsheng WU		
14:00–15:00	**Jinsong WU**	Quantum Fourier analysis
15:00–16:00	**Elena GIORGI**	Physical-space estimates on black hole perturbations
16:00–17:00	**Peng SHAN**	Geometric models for center of quantum groups
17:00–18:00	**Qiang WEN**	Island phase as a property of quantum state and Hilbert space
Dinner		
Chair: Qi WANG		
19:30–20:30	**Guchuan LI**	Periodicities in chromatic homotopy theory at prime 2
20:30-21:30	**Yinan WANG**	Geometric classifications of 5d SCFTs

Section 2

Zoom number: 276 366 7254   Password: YMSC

Time		Applied Mathematics
		Chair: Shuanhong WANG
08:00-9:00		Break
09:00-10:00	**Jijun LIU**	Inverse problems in magnetic resonance electrical impedance tomography (MREIT)
10:00–11:00	**Momiao XIONG**	Manifold Learning and Causal Inference for Drug Repurposing
11:00–12:00	**Tiexiang LI**	3D Computational Conformal Geometry with Applications on Medical Images
		Lunch
		Chair: Haibing WANG
14:00–15:00	**Jianxian QIU**	Multi-resolution HWENO schemes for hyperbolic conservation laws
15:00–16:00	**Yanfei JING**	Recent progress on block GMRES-type solvers for linear systems with multiple right-hand sides
16:00–17:00	**Hongxing RUI**	An EMA-conserving, pressure-robust and Re-semi-robust reconstruction method for simulation of incompressible Navier–Stokes equations
17:00–18:00	**Lingyun QIU**	Non-line-of-sight imaging
		Dinner
		Chair: Chuangqiang HU
19:30–20:30	**Shuo YANG**	Convergent finite element approximation of liquid crystals polymer networks
20:30–21:30	**Zhaoli GUO**	Discrete unified gas kinetic scheme for multiscale flows and beyond

December 27th, Tuesday

Section 1

Zoom number: 892 226 4912   Password: YMSC

Time		Pure Mathematics
		Chair: Xu SHEN
08:00-09:00	**Zijian YAO**	The Halo conjecture for GL2

09:00-10:00	**Yongquan HU**	Some recent progress on p-adic Jacquet-Langlands correspondence for $GL_2(\mathbb{Q}_p)$
10:00–11:00	**Xin WAN**	Iwasawa main conjecture for universal families
11:00–12:00	**Yang CAO**	Hasse principle for integral points and cohomological obstruction
Lunch		
Chair: Yichao TIAN		
14:00–15:00	**Jie MA**	Results on 4-cycles in extremal graph theory
15:00–16:00	**Jinbang YANG**	Constructing abelian varieties from rank 2 Galois representations
16:00–17:00	**Koji SHIMIZU**	Robba site and Robba cohomology
17:00–18:00	**Yupeng WANG**	The de Rham crystals over O_K
Dinner		
Chair: Mao SHENG		
19:30–20:30	**Jinxing XU**	A higher-dimensional Chevalley restriction theorem for orthogonal groups
20:30-21:30	**Zebao ZHANG**	M^{gp}-filtered complexes

Section 2

Zoom number: 276 366 7254   Password: YMSC

Time	**Applied Mathematics**	
Chair: Meng CAO		
8:00–9:00	**Jun WANG**	Fast Integral Equation Methods - Opportunities and Challenges
9:00–10:00	**Chenglong BAO**	Memory-efficient Anderson Mixing Methods and their Applications
Chair: Yuewei DAI		
10:00–11:00	**Wenhao ZHANG**	(Group) symmetry: a designing principle of neural information processing in the brain?
11:00–12:00	**Haikun ZHAO**	浅谈数学在台风科学研究中的应用
Lunch		
Chair: Fei LONG		
14:00–15:00	**Ligang LIU**	When Art Meets Math
15:00–16:00	**Dong WANG**	医学成像：模型驱动VS数据驱动

16:00-17:00	**Zhao QING**	The temporal dynamic of large scale network in human brain
17:00-18:00	**Zaixu CUI**	脑结构与功能网络研究
Dinner		

December 28th, Wednesday

Section 1

Zoom number: 892 226 4912 Password: YMSC

Time	**Pure Mathematics**	
Chair: Yingying ZHANG		
08:00-09:00	**Siyuan MA**	Price's law and Strong Cosmic Censorship for linearized fields in Kerr spacetimes
09:00-10:00	**Yang LI**	Complete Calabi-Yau metrics in the complement of two divisors
10:00-11:00	**Chen ZHAO**	L2-extension of adjoint bundles and Kollar's conjecture
11:00-12:00	**Ngaiming MOK**	Journey from Complex Geometry to the World of Numbers
Lunch		
Chair: Yi LI		
14:00-15:00	**Bing WANG**	Topological and geometric rigidity results related to the Ricci flow
15:00-16:00	**Honghao GAO**	Legendrian knots and cluster algebras via augmentations
16:00-17:00	**Zuoqin WANG**	Semiclassical oscillating functions of isotropic type and their applications
17:00-18:00	**Conan LEUNG**	Constructing SYZ mirror with Maurer-Cartan equations
Dinner		
Chair: Yi LI		
19:30-20:30	**Hao XU**	Spectral rigidity of Kähler manifolds

Section 2

Zoom number: 276 366 7254 Password: YMSC

Time	Applied Mathematics	
Chair: Yuval PERES		
09:00-10:00	**Zhan SHI**	TBA
10:00–11:00	**Guangqu ZHENG**	On the deep-water and shallow-water limits of the intermediate long wave equation from a statistical viewpoint
11:00–12:00	**Xin CHEN**	Stochastic homogenization for jump process
Lunch		
Chair: Wuyue YANG		
14:00–15:00	**Liping ZHU**	Test the effects of high-dimensional covariates via aggregating cumulative covariance
15:00–16:00	**Chenlin GU**	Quantitative homogenization of interacting particle systems
16:00–17:00	**Senya SHLOSMAN**	KPZ scaling and Tracy-Widom distribution in statistical mechanics
17:00–18:00	**Falai CHEN**	Boundary Correspondence for Iso-geometric Analysis Based on Optimal Mass Transport

December 29th, Thursday

Section 1

Zoom number: 892 226 4912 Password: YMSC

Time	Pure Mathematics	
Chair: Lars ANDERSON		
08:00-09:00	**Greg GALLOWAY**	TBA
09:00-10:00	**Linzhe Huang**	Quantum Inequalities and Unitary Categorification
10:00–11:00	**Po-Ning CHEN**	TBA
11:00–12:00	**Yanlin WANG**	Nonlinear asymptotic stability of the hydrostatic equilibrium for some gaseous stars with vacuum free boundary
Lunch		
Chair: Bowen ZHAO		

14:00–15:00	**Hongfei SHU**	Correlation functions in TsT/single trace TTbar correspondence
15:00–16:00	**Feida JIANG**	Oblique problems for nonlinear equations with augmented Hessian matrices
16:00–17:00	**Jeremie SZEFTEL**	The nonlinear stability of Kerr for small angular momentum
17:00–18:00	**Zoe WYATT**	The Dirac–Klein-Gordon equations in two spatial dimensions
Dinner		
Chair: Bowen ZHAO		
19:30–20:30	**Qian WANG**	Rough solutions of the 3-D compressible Euler equations

Section 2

Zoom number: 276 366 7254 Password: YMSC

Time	**Applied Mathematics**	
Chair: Senya SHLOSMAN		
09:00-10:00	**Jie WU**	Topological Approaches to Data and Complex Network
10:00-11:00	**Shaoyuan WU**	
11:00–12:00	**Yuehua CUI**	Mendelian randomization for causal inference on longitudinal traits
Lunch		
Chair: Wuyue YANG		
14:00–15:00	**Jian DING**	Combinatorial statistics: a common theme and a few examples
15:00–16:00	**Fan YANG (M)**	Bulk universality and quantum unique ergodicity of random band matrices
16:00–17:00	**Dangzheng LIU**	Phase Transition of eigenvalues in Non-Hermitian Random Matrix Theory

Section 3

Zoom number: 849 963 1368 Password: YMSC

Time	String Theory	
Chair: Pengxiang HAO		
08:00-09:00	**Nima ARKANI-HAMED**	TBA
09:00-10:00	**Junya YAGI**	Defects, branes and 3D lattice model
10:00–11:00	**Zhifei ZHU**	Systolic inequality on Riemannian manifold with bounded Ricci curvature
11:00–12:00	**Arnav TRIPATHY**	Singular equivariant instantons and K3 metrics
Lunch		
Chair: Wei CUI		
14:00–15:00	**Sergio CECOTTI**	TBA
15:00–16:00	**Matthew MAGILL**	Refinements of G_2 structures
16:00–17:00	**Fengjun XU**	Topological Defect Lines in 2D (Fermionic) CFTs
17:00–18:00	**Pengxiang HAO**	BMS field theories
Dinner		
Chair: Pengxiang HAO		
19:30–20:30	**Wenjie MA**	Missing Corner in the Sky: Massless Three-Point Celestial Amplitudes
20:30-21:30	**Wei CUI**	MSW-type compactifications of 6d (1, 0) SCFTs on 4-manifolds

List of Abstracts

December 22nd, Thursday

Groups of symmetry

Caucher BIRKAR

Yau Mathematical Sciences Center, Tsinghua University

Symmetry originates in the intuitive idea of symmetry of simple geometric shapes. But it appears everywhere in mathematics in different forms. In this talk we discuss symmetry and the groups they form starting with simple examples and gradually moving to more advanced examples in algebraic geometry. The first half of the talk will be accessible to undergraduate students.

Introduction to resurgence

Maxim KONTSEVICH

Institut des Hautes Études Scientifiques

Abstract

From Laplacian growth to competitive erosion

Yuval PERES

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

Laplacian growth is the study of interfaces that move in proportion to harmonic measure. Physically, it arises in fluid flow and electrical problems involving a moving boundary. We survey progress over the last decade on discrete models of (internal) Laplacian growth, including the abelian sandpile, internal DLA (first analyzed by Lawler, Bramson and Griffeath in 1992), rotor aggregation, and the scaling limits of these models on the lattice as the mesh size goes to zero. (My own work on the subject has been joint with Lionel Levine and Shirshendu Ganguly.) Most growth models can induce a model of competing growth; for internal DLA, this leads to competitive erosion. We establish conformal invariance of competitive erosion on discretizations of smooth, simply connected planar domains.

Mathematics in Internal Waves: mode-2 solitary waves in 3-layer flows

Paul MILEWSKI

University of Bath

The ocean and atmosphere are stratified fluids. Stratified fluids with narrow regions of rapid density variation with respect to depth (pycnoclines) are often modelled as layered flows. In this talk we shall examine horizontally propagating internal waves of the second baroclinic mode (mode-2) within a three-layer fluid. We will be presenting numerical solutions to both the full Euler equations and to a reduced fully-nonlinear, weakly dispersive model, the three-layer Miyata-Choi-Camassa (MCC3) equations. Mode-2 nonlinear waves (typically) occur within the linear spectrum of mode-1 waves, and are hence generically associated with an infinite energy resonant mode-1 oscillatory tail. However, in line with recent results for the MCC3 system by Barros, Choi and Milewski (JFM, 2020), we will present evidence that these oscillations can be found to have zero amplitude, resulting in families of truly localised solutions (so called embedded solitary waves) in the Euler equations. This is the first example we know of embedded solitary waves in the Euler equations.

December 23rd, Friday

Gravitational instantons and special geometry

Lars Andersson

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

Gravitational instantons are Ricci flat complete Riemannian 4-manifolds with at least quadratic curvature decay. Classical examples include the Taub-NUT and Euclidean Kerr instantons. A classification of half-flat instantons is known but the uniqueness problem remains open in general. In this talk, I will present some recent results on the classification of S^1-symmetric instantons obtained using an identity of Israel-Robinson type and the G-signature theorem, together with recent results on instantons with special geometry.

The beauty of the 3d mirror symmetry

Andrei OKOUNKOV

Columbia University

Starting from the pioneering insights of Intriligator and Seiberg many years ago, the idea of 3d mirror symmetry has been developed and applied in many important papers written by both physicists and mathematicians. Without attempting a comprehensive survey, or a detailed introduction, I will try to explain some of its marvelous features to a general audience, with an eye towards some recent results.

On p-adic comparison theorems

Yichao TIAN

Mathematics Morningside Center, Chinese Academy of Sciences

P-adic comparison theorems have been a central problems in the developments of p-adic Hodge theory, and they have important applications to various problems in arithmetic geometry and number theory. Recently, the prismatic cohomology developed by Bhatt and Scholze provide powerful tools to prove p-adic comparison theorems. In this talk, I will discuss some recent developments in this direction.

Symmetry-Resolved Density of States

Hirosi OOGURI

California Institute of Technology

It is well-known that the density of states of a unitary quantum field theory has a universal behavior at high energy. In two dimensions, it is known as the Cardy formula. When the theory has a global symmetry, it is interesting to find out how the Hilbert space is decomposed into irreducible representation of the symmetry. In this talk, I will derive universal formulas regarding the decomposition of states at high energy. The formulae are applicable to any unitary quantum field theory in any spacetime dimensions. When the AdS/CFT correspondence applies, our formulae agree with the entropy formula for the Kerr and Reissner-Nordstrom black holes. We also settle some question on the Reissner-Nordstrom black hole.

Torsion property of the zero of a Kodaira-Spencer system

Mao SHENG

Yau Mathematical Sciences Center, Tsinghua University

Given four distinct points in the complex projective line, one associates an elliptic curve with natural projection to the projective line. In this talk, I shall explain the following result: Consider a rank two motivic parabolic Higgs bundle with equal parabolic weights over P^1 with four poles and one zero. Then the zero of its Higgs field must be the image of a torsion point in the associated elliptic curve under the natural projection. Our proof relies on a very solution to the conjecture of Sun-Yang-Zuo (JEMS 2021), the Higgs periodicity theorem due to Krishnamoorthy-Sheng, and Pink's theorem (Math. Ann. 2004). This is a joint work with Xiaojin Lin and Jianping Wang.

Hermitian manifolds: when Chern connection is Ambrose-Singer

Fangyang ZHENG

Chongqing Normal University

This talk is based on joint work with Prof. Lei Ni of UCSD. We will discuss the geometry of a special type of locally homogeneous Hermitian manifolds: those whose Chern connection is Ambrose-Singer, namely with parallel torsion and curvature. We will show that the universal covering spaces of such manifolds are always the product of Hermitian symmetric spaces and complex Lie groups.

SUSY stability of higher dimensions

Pieter BLUE

University of Edinburgh

There is a large class of Kaluza-Klein type spaces given by the Cartesian product of $1+n$ dimensional Minkowski space with a Ricci-flat Riemannian manifold, called the internal space. These are solutions of the Einstein equation. We will refer to these as SUSY spacetimes. This talk will show that these spaces are stable as solutions of the Einstein equation when n is sufficiently large. This requires taking the intersection of methods for quasilinear wave and Klein-Gordon equations. This stability result is a related to a conjecture of Penrose concerning the validity of string theory. This is joint work with Lars Andersson, Zoe Wyatt, and Shing-Tung Yau.

Infinitesimal extension of adjoint forms in Kähler setting and applications

Junyan CAO

Université Côte d'Azur

We will report on a recent joint work with Mihai Paun. We present an analytic version of M. Levine's approach for the extension of pluricanonical forms in Kähler setting. The techniques we are developing can be applied to obtain an "injectivity" result conjectured by O. Fujino.

A sheaf theoretic approach to overconvergence of étale (ϕ, Γ)-modules

Heng DU

Yau Mathematical Sciences Center, Tsinghua University

The theory of (ϕ, Γ)-modules introduced by Fontaine describes $\mathbb{Q}_p$-valued continuous representations of the absolute Galois group of a p-adic field in terms of semi-linear algebra objects. There is a refinement of Fontaine's result by Cherbonnier and Colmez that replace the Cohen rings used by Fontaine with smaller rings consisting of overconvergent elements. Recently there is a sheaf theoretic approach to the theory of (ϕ, Γ)-modules by Bhatt and Scholze using prismatic Laurent F-crystals. In this talk, we will prove the analog result of Cherbonnier and Colmez in the context of Bhatt-Scholze. We will also talk about some applications. This is based on joint work with Tong Liu.

Angular momentum in general relativity

Mu-Tao WANG

Columbia University

Two black holes rotate about each other and eventually merge into a single black hole. How does one measure the angular momentum carried away by gravitational radiation during this merger? This has been a subtle issue since the 1960’s due to the existence of "supertranslation ambiguity”: the angular momentums recorded by two observers of the same system may not be the same.

In this talk, I shall describe how the mathematical theory of quasilocal mass and optimal isometric embedding identifies a new definition of angular momentum that is free of any supertranslation ambiguity. In addition, some recent development of the cross-section continuity of the angular momentum definition will also be discussed. This is based on joint work with Po-Ning Chen, Jordan Keller, Daniel Paraizo, Robert Wald, Ye-Kai Wang, and Shing-Tung Yau.

Optimization on Stiefel Manifold and Nonlinear Eigenvalue problem

Rencang LI

University of Texas at Arlington and Hong Kong Baptist University

Optimization problems on Stiefel Manifolds arise frequently in machine learning models. In this talk, we will present a solution framework via NEPv (nonlinear eigenvalue problem with eigenvector dependency) to numerically solve such problems. Optimization problems on Stiefel Manifolds arise frequently in machine learning models. In this talk, we will present a solution framework via NEPv (nonlinear eigenvalue problem with eigenvector dependency) to numerically solve such problems.

Mediation analysis with mediator and outcome missing not at random

Fan YANG (F)

Yau Mathematical Sciences Center, Tsinghua University

Mediation analysis is widely used for investigating direct and indirect causal pathways through which an effect arises. However, many mediation analysis studies are often challenged by missingness in the mediator and outcome. In general, when the mediator and outcome are missing not at random, the direct and indirect effects are not identifiable without further assumptions. In this work, we study the identifiability of the direct and indirect effects under some interpretable missing not at random mechanisms. We evaluate the performance of statistical inference under those assumptions through simulation studies and illustrate the proposed methods via the National Job Corps Study.

Growth Network: A Statistical Physics Theory to Wire Up All Growth Genes

Rongling WU

Beijing Institute of Mathematical Sciences and Applications

Growing evidence shows that almost all complex traits, like growth, are controlled by all genes an organism may carry throughout its genome. Given that each gene exerts its effect depending on the effects of other genes in a nonlinear manner, statistical dissection of the effects of all genes is an epistemological challenge. Here, we circumvent this issue by developing a statistical physics theory derived from the interdisciplinary combination of evolutionary game theory, functional mapping theory, and developmental modularity theory through generalized Lotka-Volterra ordinary differential equations. This theory enables the coalescing of all genes into multilayer and multiplex networks filled with bidirectional, signed, and weighted interactions, with which to trace the roadmap of how each gene spreads its information towards the phenotype. We design and conduct two complementary genetic experiments using Euphrates poplar, which have not only validated the biological relevance of this theory, but also gained new insight into the genetic control of growth traits. We anticipate that this theory can potentially open up a new avenue to study complex biology.

Numerical reconstruction of locally rough surfaces by a Newton iterative algorithm

Jiaqing YANG

Xi’an Jiaotong University

In this talk, I will report a Newton iterative algorithm to numerically reconstruct a locally rough surface with Dirichlet and impedance boundary conditions by near-field measurements of acoustic waves. The algorithm relies on the Frechet differentiability analysis of the locally rough surface scattering problem, which is established by reducing the original model into an equivalent boundary value problem with compactly supported boundary data. With a slight modification, the algorithm can be also extended to reconstruct the local perturbation of a non-local rough surface. Finally, numerical results are presented to illustrate the effectiveness of the inversion algorithm with the multi-frequency data.

海洋中的神秘乐章-水声隐蔽通信

Yuewei DAI

Nanjing Center for Applied Mathematics

水声通信作为水下空间中最主要的通信技术越来越受到人们的重视，但是由于水下空间是自由共享空间，加之传播介质的复杂多变，使得在水声信道中实现隐蔽通信更加困难。本报告将从多媒体信息隐藏的基本原理出发，对多类典型水声噪声源进行分析比较，针对船舶辐射噪声的特点构建隐蔽通信方案，介绍核心算法思想及相关实验情况。

Physics-informed low-temperature plasma simulation and its acceleration technology

Linlin ZHONG

School of Electrical Engineering, Southeast University

Plasma is an electrically quasi-neutral medium consisting of electrons, ions, and neutral atoms or molecules in a gaseous state. It has a wide range of industrial applications, especially for low-temperature plasmas, such as electronic manufacturing, material synthesis, arc interruption, combustion ignition, space propulsion, waste treatment, and even biological medicine. To understand and control plasma behavior in various plasma assisted applications, many computational plasma physics models have been developed in the past few decades. The typical procedure of plasma simulation includes at least the sophisticated meshing on the defined computational domain, the discretization of plasma partial differential equations (PDEs) on the meshes, and the numerical solving of discretized PDEs. Due to the irregular geometry and complex coupling relationship of multi-physics in real-world applications, the classical plasma modeling sometimes encounters difficulties in meshing, discretizing, and numerical solving, leading to poor convergence and even divergence of plasma simulation. Following the works on Physics-Informed Neural Networks (PINNs), we propose two general AI-driven frameworks for low-temperature plasma simulation: Coefficient-Subnet Physics-Informed Neural Network (CS-PINN) and Runge-Kutta Physics-Informed Neural Network (RK-PINN). CS-PINN uses either a neural network or an interpolation function (e.g. spline function) as the subnet to approximate solution-dependent coefficients (e.g. electron-impact cross sections, thermodynamic properties, transport coefficients, et al.) in plasma equations. Based on this, RK-PINN incorporates the implicit Runge-Kutta formalism in neural networks to achieve a large-time-step prediction of transient plasmas. Both CS-PINN and RK-PINN learn the complex non-linear relationship mapping from spatiotemporal space to the equation's solution. However, a well-trained PINN requires tens of thousands of optimizing iterations for complex modeling and huge neural networks, which is very time-consuming. As a result, we further propose a meta-learning method, namely Meta-PINN, to reduce the training time of PINN-based plasma simulation. In Meta-PINN, the meta network is first trained by a two-loop optimization on various training tasks of plasma modeling, and then used to initialize the PINN-based network for new tasks. Several cases including kinetic and fluid modeling of low-temperature plasmas are demonstrated as preliminary applications to validate the proposed methods.

Emergent behaviors of the Justh-Krishnaprasad model with uncertain communications

Hui YU

Yau Mathematical Sciences Center, Tsinghua University

We present a stochastic Justh–Krishnaprasad flocking model describing interactions among individuals in a planar domain with their positions and heading angles. The deterministic counterpart of the proposed model describes the formation of nematic alignment in an ensemble of planar particles moving with a unit speed. When the noise is turned off, we show that the nematic alignment state, in which all heading angles are either same or the opposite, is nonlinearly stable using a Lyapunov functional approach. We employed a diameter-like functional via the rearrangement of heading angles in the 2π-interval. In contrast, under the additive noise, a continuous angle configuration will be deviated asymptotically from the nematic state. Nevertheless, in any finite-time interval, we will see that some part of angle configuration will stay close to the nematic state with a positive probability, where we call this phenomenon as stochastic persistency. We provide a quantitative estimate on the probability for stochastic persistency and compare several numerical examples with analytical results.

December 24th, Saturday

Geometry of 4 dimensional Calabi-Yau metrics

Song SUN

University of California, Berkeley

Abstract

F-zips with additional structure on splitting models of Shimura varieties

Xu SHEN

Mathematics Morningside Center, Chinese Academy of Sciences

We will talk about some mod p Hodge structures on the Pappas-Rapoport splitting models of Shimura varieties with good reduction. These integral models are resolutions of singularities of the corresponding canonical models for ramified groups. We will also discuss some applications to coherent cohomology and Galois representations. This is a joint work with Yuqiang Zheng.

Symmetric spaces and Yang-Mills theory on open-closed surfaces

Nicolai RESHETIKHIN

Yau Mathematical Sciences Center, Tsinghua University

Open-closed surface is a surface with stratified boundary. Such surfaces have boundary with corners and is stratified by two types of strata: one is equipped with the gauge group G, simple, compact, the other with its subgroup K of fixed points of Cartan involution on G. They can be glued along G-strata. It turned out that partition functions of Yang-Mills theory on such surfaces are solutions to non-stationary spin Calogero-Moser equations corresponding to the symmetric pair (K,G)

On Entropy Bounded Strong Solutions to The Compressible Navier-Stokes Equations with Far Fields Vacuum

Zhouping XIN

Chinese University of Hong Kong

The dynamics of the vacuum state is one of the challenging issues for viscous and heat conductive compressible fluids which are governed by the full compressible Navier-Stokes equations (CNS). In the presence of vacuum, the CNS are strongly degenerate, which lead to many new phenomena such as instantaneous and finite blow-up of entropy bounded solutions and breakdown of either the total momentum or the total energy, and great difficulties associated with both local and global well-posedness of strong solutions. In particular, since the entropy is one of the most important physical states and it's equation is highly singular near vacuum, so the propagation of boundedness of the entropy in the presence of far fields vacuum is of great importance. In this talk, I will discuss some of key issues in studying the full Navier- Stokes system and present some recent results on entropy-bounded strong solutions to the CNS with both constant viscosity and heat conductivity coefficients and the degenerate temperature-dependent viscosity case. This talk is based on joint works with Jinkai Li, and Qin Duan - Shengguo Zhu.

FAST-NN for Big Data Modeling

Jianqing FAN

Princeton University

We introduce a Factor Augmented Sparse Throughput (FAST) model that utilizes both latent factors and sparse idiosyncratic components for nonparametric regression. The FAST model bridges factor models on one end and sparse nonparametric models on the other end. It encompasses structured nonparametric models such as factor augmented additive model and sparse low-dimensional nonparametric interaction models and covers the cases where the covariates do not admit factor structures. Via diversified projections as estimation of latent factor space, we employ truncated deep ReLU networks to nonparametric factor regression without regularization and to more general FAST model using nonconvex regularization, resulting in factor augmented regression using neural network (FAR-NN) and FAST-NN estimators respectively. We show that FAR-NN and FAST-NN estimators adapt to unknown low-dimensional structure using hierarchical composition models in nonasymptotic minimax rates. We also study statistical learning for the factor augmented sparse additive model using a more specific neural network architecture. Our results are applicable to the weak dependent cases without factor structures. In proving the main technical result for FAST-NN, we establish new a deep ReLU network approximation result that contributes to the foundation of neural network theory. Our theory and methods are further supported by simulation studies and an application to macroeconomic data. (Joint work with Yihong Gu)

Low-rank Methods for Bayesian Inverse Problems

Yue QIU

Shanghai Jiao Tong University

In this talk, I will introduce our recent work on low-rank methods for Bayesian inverse problems. For linear problems with Gaussian noise and Gaussian prior, the posterior is also Gaussian and characterized by the posterior mean and covariance. We propose a low rank Arnoldi method to approximate the large dense posterior covariance matrix by making use of tensor computations. For nonlinear systems, the posterior is not Gaussian anymore, however, can often be approximated by a Gaussian distribution using the ensemble Kalman filter (EnKF) or the extended Kalman filter (ExKF). We propose a randomized low-rank method to reduce the computational complexity of the EnKF. We use numerical experiments to show the efficiency of our low-rank methods. This is joint work with Peter Benner and Martin Stoll.

Randomized Algorithms for Discrete Ill-Posed Problems

Liping ZHANG

Zhejiang University Of Technology

We propose randomized GSVD algorithms and a randomized core reduction for the ill-posed problem with the tolerance as a regularization parameter. In theory and numerical experiments, we show that the randomized algorithms are competitive with the truncated GSVD/TLS in accuracy and more efficient in time and storage. For the large-scale problem, the coefficient matrix does not need to be explicit.

Streaming Algorithms for Matrix Approximation

Luo LUO

Fudan University

In this talk, we introduce the matrix sketching algorithms in the row-updates model. For symmetric positive definite matrix, we introduce the idea of regularized matrix approximation and its application in streaming model, which leads to the more accurate and more well-conditioned estimation than the results of classical low-rank based algorithms. For the general streaming matrix multiplication, we introduce the sharper error bound of co-occurring directions and its extension for sparse inputs. We also discuss time and space optimality of these algorithms.

December 26th, Monday

Perturbative causal shadows in AdS/CFT

Huajia WANG

University of Chinese Academy of Sciences (UCAS), Kavli Institute for Theoretical Sciences (KITS)

Bulk reconstruction is an important subject in AdS/CFT that aims to reveal the crucial mechanism underlying the duality. In the context of subregion duality, there is a notion called the causal shadow that emerges from the entanglement wedge reconstruction proposal. It encodes deep aspects of bulk reconstruction beyond causality. In this talk, I will explain the various aspects related to causal shadow, and give an analysis of their formation and properties in perturbation theory.

Introduction to Arithmetic Statistics

Weitong WANG

Southeast University

In the development of number theory, people use the method of analysis and probability theory to study the problems including counting number fields, study of the distribution of class groups and so on. Not only we have some proven results like counting cubic fields and the distribution of the 3-torsion part of the class group of quadratic number fields, but also some conjectural statements like Malle-Bhargava Heuristics and Cohen-Lenstra-Martinet Heuristics. In this talk, I'll try to make a brief introduction to these topics.

Directed harmonic currents near non-hyperbolic linearizable singularities

Zhangchi Chen

Mathematics Morningside Center, Chinese Academy of Sciences

Let $(\mathbb{D}^2, \mathscr{F}, \{0\})$ be a singular holomorphic foliation on the unit bidisc $\mathbb{D}^2$ defined by the linear vector field

$$z\,\frac{\partial}{\partial z} + \lambda\, w\,\frac{\partial}{\partial w},$$

where $\lambda \in \mathbb{C}^*$. Such a foliation has a non-degenerate singularity at the origin $0 := (0,0) \in \mathbb{C}^2$. Let T be a harmonic current directed by $\mathscr{F}$ which does not give mass to any of the two separatrices $(z = 0)$ and $(w = 0)$. Assume $T \neq 0$. The Lelong number of T at 0 describes the mass distribution on the foliated space.

In 2014 Nguyên proved that when $\lambda \notin \mathbb{R}$, i.e. when 0 is a hyperbolic singularity, the Lelong number at 0 vanishes. Suppose the trivial extension $\tilde{T}$ across 0 is dd^c-closed. For the non-hyperbolic case $\lambda \in \mathbb{R}^*$, we prove that the Lelong number at 0:

1) is strictly positive if $\lambda > 0$;

2) vanishes if $\lambda \in \mathbb{Q}_{<0}$;

3) vanishes if $\lambda < 0$ and T is invariant under the action of some cofinite subgroup of the monodromy group.

This work is published on Ergodic Theory and Dynamical Systems in 2022.

How fundamental groups of algebraic varieties determine their hyperbolicity

Ya DENG

CNRS, Institut Élie Cartan de Lorraine, Université de Lorraine

It is natural to ask whether one can characterize the hyperbolicity of algebraic varieties (e.g. positivity of their logarithmic canonical bundle, algebraic degeneracy of entire curves) via their topology. In this talk, I will answer this question if their fundamental groups admit a linear representation. Precisely, I will give a sharp condition for the hyperbolicity of complex quasi-projective varieties via representation of fundamental groups. This fits well with the prediction of the strong Green-Griffiths-Lang conjecture. The proof is based on Nevanlinna theories, and non-abelian Hodge theories in both Archimedean and non-archimedean settings.

Quantum Fourier analysis

Jinsong WU

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

Quantum Fourier analysis is a subject studying quantum symmetries such as subfactors, tensor categories, locally compact quantum groups by means of Fourier analysis. In this talk, we will present numbers of inequalities for quantum symmetries inspired from the Fourier analysis. These inequalities turn out to be useful in many aspects such as the classification of subfactors, unitary categorification etc.

Physical-space estimates on black hole perturbations

Elena GIORGI

Columbia University

Most works on the analysis of the wave equation on Kerr black holes rely on a combination of the vector field method and Fourier decomposition, with the notable exception of a generalized vector field method introduced by Andersson-Blue. Their method allows for commutation with second order differential operators entirely in physical-space by supplementing the Killing vector fields with the Carter operator of Kerr to obtain a local energy decay identity at the level of three derivatives of the solution for sufficiently small $|a|$. In this talk, I will describe the main ideas of Andersson-Blue's method and explain its advantages in two recent applications where physical space-estimates have been crucial: the linear stability of Kerr-Newman black hole to coupled gravitational-electromagnetic perturbations and our proof of the non-linear stability of the slowly rotating Kerr family with Klainerman-Szeftel.

Geometric models for center of quantum groups

Peng SHAN

Yau Mathematical Sciences Center, Tsinghua University

I will explain geometrical realizations of the center of different versions of quantum groups in terms of singular cohomology of varieties associated with affine Lie algebras.

Island phase as a property of quantum state and Hilbert space

Qiang WEN

Southeast University

In this talk, I will give a purely quantum information perspective for the Island formula. More explicitly we show that, in a quantum system when the state of a subset is totally encoded in the state of another subset, the Hilbert space of the system will reduce, and the way we compute the reduced density matrix and related entropy quantities will also change essentially. Such reductions of the Hilbert space result in a new island formula in quantum systems, which we conjecture to be the same island formula in gravity recently proposed to rescue the unitarity for black hole evaporation. Furthermore, we propose a non-gravitational field theory configuration where entanglement islands emerge, give a description for the entanglement structure of the island phase and propose how to realize the island phase in the lab.

Periodicities in chromatic homotopy theory at prime 2

Guchuan LI

Max Planck Institute for Astronomy, University of Michigan

Chromatic homotopy theory uses the algebraic geometry of smooth 1-parameter formal groups to separate stable homotopy theory into periodic layers. The 1st layer recovers the image of Adams' J homomorphism and the real Bott periodicity of the real topological K-theory KO. In this talk, I will present a generalization of the real Bott periodicity of KO to general layers at prime 2. The proof takes inspiration from the breakthroughs of Hill—Hopkins—Ravenel's solution to Kervaire invariant one problem. This is based on joint works with Zhipeng Duan, XiaoLin Danny Shi, Guozhen Wang, and Zhouli Xu.

Geometric classifications of 5d SCFTs

Yinan WANG

Peking University

In this talk, I will overview the recent developments in the classification of 5d SCFTs from M-theory on canonical threefold singularities. In this geometric framework, the Coulomb branch data of the 5d SCFTs can be read off from the resolved CY3, which is studied in the cases of isolated singularities, elliptic models and orbifold singularities. The Higgs branch information of the 5d SCFTs is encoded in the deformation of the singularity, which is applied to the cases of isolated singularities. A new conjecture of 5d/4d correspondence is proposed based on the latter observations.

Inverse problems in magnetic resonance electrical impedance tomography (MREIT)

Jijun LIU

Southeast University

The researches on biomedical imaging and modelling have received extensive attention. Magnetic resonance electrical impedance tomography (MREIT) aims to reconstruct the high spatial resolution conductivity image at low frequency. The mathematical model of MREIT is an inverse problem for elliptic partial differential equation in divergence form with a nonlocal Neumann boundary condition. In this talk we will present MREIT reconstruction models and algorithms from two injection currents and single injection current. Meanwhile, the convergence theories of the corresponding iterative algorithms will be provided. At last we will provide several numerical and phantom experimental results to validate the theoretical results.

Manifold Learning and Causal Inference for Drug Repurposing

Momiao XIONG[1]***, Tao XU***[2] ***and Jinying ZHAO***[2]

[1] Department of Biostatistics and Data Science, University of Texas School of Public Health
[2] Department of Epidemiology, University of Florida

Traditional drug discovery and development are expansive and time-consuming. Alternative strategy to de novo drug discovery is drug repurposing which attempts to identify the novel drug-target interactions. Drug's ability to reverse altered gene expressions (over-expressed or under-expressed in disease samples compared to normal samples) is the key concept behind various drug repurposing studies. The current approaches to drug repurposing studies have two serious limitations. First limitation is that the identified altered gene expression depends on individual gene analysis. Second limitation is lack of causal reasoning. Most computational methods for drug repurposing studies use association (or relation) analysis, which cannot provide true signals for drug targets. To overcome these limitations, we propose a manifold learning and causal inference-based framework for drug repurposing. The framework consists of two classes of problems: (1) characterizing the structure of the data and dealing with analyzing functions defined on a given non-Euclidean domain. To solve the first problem, we use graph neural networks (GNN) to learn causal structure networks of both drug-target and disease specific gene expressions. We formulate causal graph learning as a continuous optimization problem to reconstruct the large directed graph with 1,000 genes. To solve the second problem, we use directed acyclic graph neural network (DAGNN) to process and summarize information according to the flow defined by the DAGNN. To reverse the altered expressions of the genes defined on DAGNN in disease samples, we develop a novel method for causal analysis in manifold. The proposed methods are applied to drug-repurposing for COVID-19.

3D Computational Conformal Geometry with Applications on Medical Images

Tiexiang LI

Southeast University

In this talk, we would like to introduce the computational conformal geometry with its applications on medical images. The well-known uniformization theorem shows that a closed surface of genus-zero is equivalently conformal to a unit sphere. However, the numerical method and its convergence should be addressed. We will propose efficient algorithms on conformal energy minimization (CEM), stretch energy minimization (SEM) and volume stretch energy minimization (VSEM) for finding the conformal (angle-preserving) and equiareal (area-preserving) parametrizations, respectively, between a simply connected closed surface and a sphere, as well as, the volume-preserving parametrization between a 3-manifold with a single genus-zero boundary and a unit ball. Based on the SEM and VSEM algorithms we further develop the reliable and robust algorithms for solving the optimal mass transportation (OMT) between an irregular 3D domain and a unit ball, while minimizing the deformation cost, and keeping the minimal distortion and the local mass ratios unchanged. Combining the proposed OMT with the U-net machine learning algorithm, we develop a novel two-phase OMT algorithm successfully applying for the detection and segmentation of 3D brain tumors with high training and validation Dice scores.

Multi-resolution HWENO schemes for hyperbolic conservation laws

Jianxian Qiu

School of Mathematical Sciences and Fujian Provincial Key Laboratory of Mathematical Modeling and High-Performance Scientific Computing, Xiamen University

In this presentation, a high-order moment-based multi-resolution Hermite weighted essentially non-oscillatory (HWENO) scheme is designed for hyperbolic conservation laws. The main idea of this scheme is derived from our previous work [J. Comput. Phys., 446 (2021) 110653], in which the integral averages of the function and its first order derivative are used to reconstruct both the function and its first order derivative values at the boundaries. However, in this paper, only the function values at the Gauss-Lobatto points in the one or two dimensional case need to be reconstructed by using the information of the zeroth and first order moments. In addition, an extra modification procedure is used to modify those first order moments in the troubled-cells, which leads to an improvement of stability and an enhancement of resolution near isContinuities.

To obtain the same order of accuracy, the size of the stencil required by this moment-based multi-resolution HWENO scheme is still the same as the general HWENO scheme and is more compact than the general WENO scheme. Moreover, the linear weights are not unique and are independent of the node position, and the CFL number can still be 0.6 whether for the one or two-dimensional case, which has to be 0.2 in the two dimensional case for other HWENO schemes.

Recent progress on block GMRES-type solvers for linear systems with multiple right-hand sides

Yanfei JING

School of Mathematical Sciences, University of Electronic Science and Technology of China

We give a talk on our recent progress in block GMRES-type solvers for linear systems with multiple right-hand sides. We particularly illustrate from the point of view of subspace decomposition the idea of Robbe and Sadkane’s inexact breakdown mechanism and its detection technique in the classical block GMRES method, and show merits on our solvers with such partial convergence management by some typical numerical experiments.

An EMA-conserving, pressure-robust and Re-semi-robust reconstruction method for simulation of incompressible Navier–Stokes equations

Hongxing RUI

School of Mathematics, Shandong University

Proper EMA-balance (E: kinetic energy; M: momentum; A: angular momentum), pressure-robustness and Re-semi-robustness (Re: the Reynolds number) are three important properties of Navier-Stokes simulations with exactly divergence-free elements. However, the construction of these elements is not trivial in most cases. In this talk, based on the pressure-robust reconstruction methods in [A. Linke and C. Merdon, Comput. Methods Appl. Mech. Engrg. 311 (2016], we propose a novel reconstruction method for a class of non-divergence-free simplicial elements which admits almost all the above properties. The only exception is the energy balance, where kinetic energy should be replaced by a properly discrete form. Some numerical comparisons with exactly divergence-free methods, pressure-robust reconstructions and the EMAC scheme are provided to confirm our theoretical results. This is a jointed work with Dr. Xu Li.

Non-line-of-sight imaging

Lingyun QIU

Yau Mathematical Sciences Center, Tsinghua University

Non-line-of-sight imaging aims at recovering obscured objects from multiple-scattered light. It has recently received widespread attention due to its potential applications, such as autonomous driving, rescue operations, and remote sensing. However, in cases with high measurement noise, obtaining high-quality reconstructions remains a challenging task. In this work, we establish a unified regularization framework, which can be tailored for different scenarios, including indoor and outdoor scenes with substantial background noise under both confocal and non-confocal settings. The proposed regularization framework incorporates sparseness and non-local self-similarity of the hidden objects as well as the smoothness of the measured signals. We show that the estimated signals, albedo, and surface normal of the hidden objects can be reconstructed robustly even with high measurement noise under the proposed framework. Reconstruction results on synthetic and experimental data show that our approach recovers the hidden objects faithfully and outperforms state-of-the-art reconstruction algorithms in terms of both quantitative criteria and visual quality.

Convergent finite element approximation of liquid crystals polymer networks

Shuo YANG

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

Liquid crystals polymeric networks (LCN) deform spontaneously upon temperature or optical actuation. This property can be exploited in the design of materials to achieve non-trivial shapes. These materials combine the features of rubber and nematic liquid crystals. In this work, we first derive a 2D membrane model from 3D neo-Hookean elasticity via formal asymptotics, where the obtained limiting model and the derivation are inspired by Virga et al., Bhattacharya et al. and Cirak et al. The membrane model consists of a minimization problem of a non-convex energy functional for deformations of the materials, and the equilibrium shapes depend on the design of blueprinted nematic orders and pre-determined actuation parameters. We discuss properties of this energy functional and its global minimizers. We design a finite element discretization for this model, propose a novel iterative scheme to solve the non-convex discrete minimization problem, and prove stability of the scheme and a convergence of discrete minimizers. We present a wide range of numerical simulations to illustrate effectiveness and efficiency of our algorithm, as well as the fact that this model captures quite rich physical phenomenon. These simulations include some results of practical interests that matches lab experiments, the design of origami shapes and a quantitative study of our numerical method.

Discrete unified gas kinetic scheme for multiscale flows and beyond

Zhaoli GUO

Huazhong University of Science and Technology

Multiscale flows appear in many scientific and engineering fields, such as rarefied gas dynamics, nano/micro-fluidics, and vacuum technology. It is a challenging problem for modeling and simulating such flows due to the large spans of temporal and spatial scales. The discrete unified gas kinetic scheme (DUGKS) is a type of numerical method for simulating multiscale transport based on kinetic theory, which has the asymptotic persevering properties and is self-adaptive. In this talk, we will report the basic structure, numerical properties, and some typical applications of DUGKS. Extensions of DUGKS beyond flow problems, such as to radiation, neutron transport, phonon transport, and electron transport, will also be presented.

December 27th, Tuesday

The Halo conjecture for GL2

Zijian YAO

Chicago University

The eigencurve is a rigid analytic curve constructed by Coleman–Mazur that p-adically interpolates eigenforms of finite slopes. The global geometry of the eigencurve is somewhat mysterious. However, over the boundary, it is predicted to behave rather nicely (by the so-called Halo conjecture). This conjecture has been studied by Liu–Wan–Xiao for definite quaternion algebras. In this talk, we will report on some recent work on this conjecture in the case of GL2. This is joint with H. Diao.

Some recent progress on p-adic Jacquet-Langlands correspondence for $\mathrm{GL}_2(\mathbb{Q}_p)$

Yongquan HU

Mathematics Morningside Center, Chinese Academy of Sciences

The classical Jacquet-Langlands (J-L) correspondence relates complex representations of GL_n and that of its inner forms. It was proved in 1970's and provides one of the first examples of the functoriality conjecture in Langlands program. However, when we consider representations with p-adic or mod p coefficients, the analogue of J-L correspondence is still poorly understood, even in the simplest case of $\mathrm{GL}_2(\mathbb{Q}_p)$. In this talk, we will report some recent progress on the p-adic and mod p J-L correspondence for $\mathrm{GL}_2(\mathbb{Q}_p)$. This is joint work with Haoran Wang (in progress).

Iwasawa main conjecture for universal families

Xin WAN

Mathematics Morningside Center, Chinese Academy of Sciences

Let p be an odd prime. We formulate and prove the Iwasawa main conjecture for the universal family in the p-adic Langlands program for elliptic modular forms. As a consequence we prove Kato's Iwasawa main conjecture for elliptic modular forms with no assumption on the ramification type at p, and prove the rank 0 BSD formula for elliptic curves at additive primes. This is joint work with Olivier Fouquet.

Hasse principle for integral points and cohomological obstruction

Yang CAO

University Of Science And Technology Of China

The Hasse principle of integral points on algebraic varieties is a basic object in Diophantine geometry. In this talk, I will firstly recall its link with strong approximation in adelic topology and its cohomological obstruction. Then I will survey my two works: comparison of several cohomological obstructions and weak version for special abelian schemes.

Results on 4-cycles in extremal graph theory

Jie MA

University Of Science And Technology Of China

The study of the 4-cycle has an important enlightening effect on the development of Extremal Graph Theory, especially degenerate Turan type problems. In this talk, we will survey important results on 4-cycles and focus on two related conjectures (a conjecture of Erdos and a conjecture of Erdos-Simonovits). Joint with Tianchi Yang.

Constructing abelian varieties from rank 2 Galois representations

Jinbang YANG

University Of Science And Technology Of China

Let U be a smooth affine curve over a number field K with a compactification X and let $\mathbb{L}$ be a rank 2, geometrically irreducible $\overline{Q}_\ell$-local system on U with cyclotomic determinant that extends to an integral model, has Frobenius traces all in some fixed number field $E \subset \overline{Q}_\ell$, and has bad, infinite reduction at some closed point x of $X \setminus U$. We show that $\mathbb{L}$ occurs as a summand of the cohomology of a family of abelian varieties over U. This is a joint work with Raju Krishnamoorthy and Kang Zuo.

Robba site and Robba cohomology

Koji SHIMIZU

Yau Mathematical Sciences Center, Tsinghua University

We will discuss a p-adic cohomology theory for rigid analytic varieties with overconvergent structure (dagger spaces) over a local field of characteristic p. After explaining the motivation, we will define a site (Robba site) and discuss its basic properties.

The de Rham crystals over O_K

Yupeng WANG

Mathematics Morningside Center, Chinese Academy of Sciences

Let O_K be a complete discrete valuation ring of mixed characteristic (0,p) with perfect residue field. In this talk, we will define and study de Rham crystals on the absolute prismatic site of O_K. If times permits, I will explain the generalization to the higher dimensional case. This is a joint work with Hui Gao and Yu Min.

A higher-dimensional Chevalley restriction theorem for orthogonal groups

Jinxing XU

University of Science and Technology of China

The classical Chevalley restriction theorem asserts that for a semisimple complex Lie group G, the ring of G-invariant polynomials on the Lie algebra g is isomorphic through restriction to the ring of Weyl group invariant polynomials on the Cartan subalgebra. In studying the Hitchin morphism of Higgs bundles over higher dimensional varieties, Chen and Ngo conjectured a multi-variable generalization of the Chevalley restriction theorem, and they proved the GL and Sp cases. We then prove the orthogonal group case and our treatment can apply to the GL and Sp cases in a uniform way. As a corollary, we can prove a multiplicative property of Pfaffians for commutative skew symmetric matrices over an arbitrary char. 0 commutative ring. This is a joint work with Lei Song and Xiaopeng Xia.

M^{gp}-filtered complexes

Zebao ZHANG

Peking University

Inspired by the ℓ-adic weight theory of Beilinson-Bernstein-Deligne-Gabber in positive characteristic, Saito established his theory of mixed Hodge modules. Besides weight filtration, a mixed Hodge module contains another filtration, i.e. the Hodge filtration. In this talk, we investigate the Hodge filtration of a mixed Hodge module in positive characteristic. This is based on a joint program with Prof. Mao Sheng.

(Group) symmetry: a designing principle of neural information processing in the brain?

Wenhao ZHANG

University of Texas, Southwestern Medical Center at Dallas

Equivariant representation is necessary for the brain and artificial perceptual systems to faithfully represent the stimulus under some (Lie) group transformations. However, it remains unknown how recurrent neural circuits in the brain represent the stimulus equivariantly, nor the neural representation of abstract group operators. The present study uses a one-dimensional (1D) translation group as an example to explore the general recurrent neural circuit mechanism of the equivariant stimulus representation. We found that a continuous attractor network (CAN), a canonical neural circuit model, self-consistently generates a continuous family of stationary population responses (attractors) that represents the stimulus equivariantly. Inspired by the Drosophila's compass circuit, we found that the 1D translation operators can be represented by extra speed neurons besides the CAN, where speed neurons' responses represent the moving speed (1D translation group parameter), and their feedback connections to the CAN represent the translation generator (Lie algebra). We demonstrated that the network responses are consistent with experimental data. Our model for the first time demonstrates how recurrent neural circuitry in the brain achieves equivariant stimulus representation.

浅谈数学在台风科学研究中的应用

Haikun ZHAO

Nanjing University of Information Science and Technology

台风作为地球上最严重的自然灾害之一，其常给我国经济造成重大的损失和人民生命构成巨大的威胁，且台风灾害随全球变暖呈日益加剧之势。全球气候变化下台风的活动是当前人类面临的一个重要问题。为此，在全球气候变化下提供有价值的台风活动预测预估是当前气象业务的核心内容和国际科学界面临的重大科学任务，同时也是国家社会可续发展的迫切需求。台风活动的预测预估通常是将大气科学与数学、物理等学科交叉结合，基于数学物理模型或模式，运用超级计算机或现代统计方法等手段，"模拟或计算"出未来的台风活动。本报告将结合自己的研究工作，从观测分析、影响机制和预测预估等方面简要介绍台风科学研究中的数学知识。

When Art Meets Math

Ligang LIU

University of Science and Technology of China

3D visual arts are highly diverse, including sculpture, architecture, ceramics, etc., in our lives. Traditionally, artists use their rich imagination and experience to design 3D objects to give the audience a memorable experience. The design process takes a lot of trial and error, so it is often very time-consuming. It has attracted the attention of many researchers in the community of geometry processing and computer graphics, proposing various algorithms to simplify the initial complicated design process and help artists quickly realize the art in their minds. In this talk, we will show a few interesting 3D visual art works and propose automatic mathematical methods to solve various problems in the design process of these art works. From these examples, we reveal how mathematical techniques successfully are applied to solve practical problems, particularly in cases of art design.

医学成像：模型驱动VS数据驱动

Dong WANG

Southeast University

医学成像是一类重要的应用科学问题，在临床诊疗中有着广泛的应用。医学临床上常用的成像方式有计算机断层扫描（CT）、磁共振成像（MRI）、正电子发射成像（PET）等。在实际应用中，医学成像通常会遇到成像时间长、辐射剂量大等问题，因此快速、低剂量、高精度成像是医学成像领域所关注的问题。从方法论的角度而言，医学成像可以分为基于模型的方法、基于数据的方法、基于数据和模型双驱动的方法。在这次报告中，我会简单回顾医学成像中的常用方法，并给出我们在快速动态MR成像、低剂量PET成像中的最新进展。

The temporal dynamic of large scale network in human brain

Zhao QING

Southeast University

In last decades, people can measure and describe how the human brain is organized into large scale structural and functional networks by medical imaging methods like MRI. Recently, studies focused on how these brain networks change at different time scales, which provided new insights to our understanding on our human brains. This talk would introduce the conceptions of dymanic brain networks on both structural and functional views, and how we apply mathematical methods like graph theory, Hilbert spectrum etc. to build such brain network models.

脑结构与功能网络研究

Zaixu CUI

Chinese Institute for Brain Research, Beijing

人类的认知与行为来源于人脑复杂网络，在微观层面由突触和轴突连接神经元而构成，在宏观层面是由白质纤维束连接脑区构建而成。本报告将介绍基于多模态磁共振成像在大尺度水平研究脑结构与功能网络的拓扑结构、以及结构网络之上功能活动传播的建模等研究问题。此外，将简要介绍几个相关的研究工作，包括个体化脑功能网络皮层分布形态在儿童青少年阶段的发育及其与认知的关联研究，以及基于网络控制论建模结构网络是如何支持功能信号的动态传播从而支持执行功能相关功能活动的。

Fast Integral Equation Methods - Opportunities and Challenges

Jun WANG

Yau Mathematical Sciences Center, Tsinghua University

During the last few decades, integral equation methods have proven to be an indispensable tool for the robust and accurate solution of elliptic partial differential equations. For parabolic equations, there is a classical potential theory which leads to elegant integral equatsion methods used for analysis, but rarely for numerical computation because of the computational complexity associated with naive implementations. If numerical methods are to play a fundamental role in design and quantitative prediction, the solution techniques will have to be high-order accurate, robust, and fast. Moreover, especially when the governing equations involve nonlinear interactions, sharp features can develop in the solution even away from domain boundaries and automatic strategies will be required for refining or coarsening the grid in spacetime. In this talk, we present the frameworks of integral equation methods for both elliptic and parabolic equations, combining functional pieces including singular numerical quadratures, fast algorithms, and methods for automatic adaptivity. Potential applications and open problems for analysts and numerical analysts alike will also be mentioned.

Memory-efficient Anderson Mixing Methods and their Applications

Chenglong BAO

Yau Mathematical Sciences Center, Tsinghua University

Anderson mixing (AM) is a useful method that can accelerate fixed-point iterations by exploring the information from historical iterations. Despite its numerical success in various applications, the memory requirement in AM remains a bottleneck when solving large-scale optimization problems in a resource-limited machine. In this talk, I will discuss the recent progress of designing the variants of Anderson mixing methods with small memory requirements. Using this attractive property, we can apply these methods for large-scale optimization problems, such as training deep neural networks. Finally, we will present extensive numerical experiments for validating our approaches.

December 28th, Wednesday

Price’s law and Strong Cosmic Censorship for linearized fields in Kerr spacetimes

Siyuan MA

Albert Einstein Institute, Max Planck Institutes

I will show the precise late-time asymptotics for linearized fields globally in Kerr exterior and interior regions, which are called the Price’s law and closely relevant to the Strong Cosmic Censorship, respectively. This is joint work with Lin Zhang.

Complete Calabi-Yau metrics in the complement of two divisors

Yang LI

Massachusetts Institute of Technology

The celebrated work of Tian and Yau in the 90s constructed complete Calabi Yau metrics on the complement of an anti canonical divisor in a Fano manifold. In the joint work with Tristan Collins we generalize the construction to allow the divisor at infinity to break into the union of two transverse smooth divisors.

L2-extension of adjoint bundles and Kollar’s conjecture

Chen ZHAO

University Of Science And Technology Of China

I will talk about Kollar’s package on the derived pushforward of the L2 extension of the dualizing sheaf twisted by a certain Hermitian vector bundle. In particular we give an L2-theoretic proof to Kollar’s conjecture, which has been proved by M. Saito via the theory of mixed Hodge module. This is a work joint with Junhao Shentu.

Journey from Complex Geometry to the World of Numbers

Ngaiming MOK

Hong Kong University

The speaker has long been interested in applications of complex geometry to number theory, and will trace the trajectory of his involvement concerning (1) abelian schemes over complex function fields, (2) commutants of Hecke correspondences on bounded symmetric domains Ω and (3) functional transcendence concerning Shimura varieties and more generally on $X_\Gamma := \Omega/\Gamma$.

For (1) we recall first results of Mok (1991) and Mok-To (1993) concerning the finiteness of Mordell-Weil groups of universal abelian varieties A_Γ without fixed parts over modular function fields $K = \mathbb{C}(\overline{X_\Gamma})$ and applications by Mok-Ng of the underlying methodology of our differential-geometric approach to the study of the Betti map, including effective finiteness results on points of Betti multiplicities ≥ 2 of a section $\sigma \in E(\mathbb{C}(\overline{X}))$ of infinite order, a topic of study initiated by Zannier et-al. For (2) we recall the reduction of a problem of Clozel-Ullmo (2003) concerning commutants of Hecke correspondences which reduces to a conjecture characterizing measure-preserving germs of holomorphic maps on Ω, and the solution of Mok-Ng (2012) using CR geometry. For (3) we will discuss the Ax-Schanuel theorem of Mok-Pila-Tsimerman (2019) for Shimura varieties and its applications to the study of rational points, and the characterization of bi-algebraicity due to Chan-Mok (2022) in the case of a projective variety $Y \subset X_{\check{\Gamma}}$, for $X_{\check{\Gamma}}$ possibly of infinite volume, uniformized by an algebraic subset $Z \subset \Omega$.

Topological and geometric rigidity results related to the Ricci flow

Bing WANG

University Of Science And Technology Of China

The Colding-Gromov gap theorem asserts that an almost non-negatively Ricci curved manifold with unit diameter and maximal first Betti number is homeomorphic to the flat torus T^n. The Bishop-Gromov volume comparison theorem implies that if a manifold has $Ric \geq n-1$ and the same volume as the one of the round sphere, then this manifold is isometric to the standard sphere S^n. These two theorems are typical topological and geometric rigidity theorems. In this talk, we shall discuss generalizations of the above rigidity theorems. For examples, using the Ricci flow smoothing technique, we show a parametrized version of the Colding-Gromov theorem, in the context of collapsing Riemannian manifolds with Ricci curvature bounded below: if a closed manifold with Ricci curvature uniformly bounded below is Gromov-Hausdorff close to a (lower dimensional) manifold with bounded geometry, and has the difference of their first Betti numbers equal to the dimensional difference, then it is diffeomorphic to a torus bundle over the one with bounded geometry. For a Ricci shrinker Gromov-Hausdorff close to standard round cylinder $S^{n-1} \times R$, we show that the shrinker itself must be isometric to the cylinder. (This even holds for $S^{n-k} \times R^k$ by Colding-Minicozzi for general $1 \leq k \leq n-2$, by a different approach.) Other rigidity examples will also be discussed. This talk is based on the joint work with S.S. Huang, Y. Li and others.

Legendrian knots and cluster algebras via augmentations

Honghao GAO

Yau Mathematical Sciences Center, Tsinghua University

Legendrian knots and their exact Lagrangian fillings are central objects to study in low dimensional contact and symplectic topology. In recent developments, cluster algebras have proven to be powerful tools to classify Lagrangian fillings. For a positive braid link, we introduce a cluster K2 structure on its augmentation variety. Using the perspective of Ekholm-Honda-Kalman theory, we prove that admissible exact Lagrangian fillings, a subset of decomposable ones, induce cluster seeds in the cluster K2 augmentation variety. We provide an algorithm to compute these cluster seeds. We also use the cluster Donaldson-Thomas transformation to produce infinitely many Lagrangian fillings. This is a joint work with L. Shen and D. Weng.

Semiclassical oscillating functions of isotropic type and their applications

Zuoqin WANG

University Of Science And Technology Of China

Rapidly oscillating functions associated with Lagrangian submanifolds play a fundamental role in semiclassical analysis. In this talk, I will describe how to associate classes of semiclassical oscillating functions to isotropic submanifolds in cotangent bundle, and show that these classes are invariant under the action of general Fourier integral operators (modulo the usual clean intersection condition). I will also discuss some special classes (coherent states, Hermite states) and their applications. The talk is based on joint works with V. Guillemin (MIT) and A. Uribe (U. Michigan).

Constructing SYZ mirror with Maurer-Cartan equations

Conan LEUNG

Chinese University of Hong Kong

In 2002, Fukaya proposed a remarkable explanation of mirror symmetry detailing the SYZ conjecture by introducing two correspondences: one between the theory of pseudo-holomorphic curves on a Calabi-Yau manifold $X^\vee$ and the multi-valued Morse theory on the base $B^\vee$ of an SYZ fibration $p^\vee : X^\vee \to B^\vee$, and the other between deformation theory of the mirror X and the same multi-valued Morse theory on $B^\vee$. We prove a reformulation of the main conjecture in Fukaya's second correspondence, where multi-valued Morse theory on the base $B^\vee$ is replaced by tropical geometry on the Legendre dual B. This is a joint work with Kwokwai Chan and Ziming Ma.

Spectral rigidity of Kähler manifolds

Hao XU

Zhejiang University

For each fixed nonnegative integers p, if a compact Kähler manifold M of complex dimension n has the same p-spectra as CP^n equipped with the Fubini-Study metric, we give explicit range of n such that this Kähler manifold is holomorphically isometric to CP^n. This extends previous works of Tanno, Chen-Vanhecke, Goldberg for p $\leq$ 2 and Li for even p. As application, we give a simple proof that if two compact Kahler manifold has the same p-spectra for all p $\geq$ 0, and one of them has constant holomorphic sectional curature, then the other also has constant holomorphic sectional curature. This is joint work with K. Liu, X. Huang and Y. Zhi.

Title

Zhan SHI

University of Chinese Academy of Sciences

Abstract

On the deep-water and shallow-water limits of the intermediate long wave equation from a statistical viewpoint

Guangqu ZHENG

University of Liverpool

We study convergence problems for the intermediate long wave equation (ILW), in the deep-water limit and the shallow-water limit from a statistical point of view. In particular, we establish convergence of invariant Gibbs dynamics for ILW in both the deep-water and shallow-water limits. For this purpose, we first construct the Gibbs measures for ILW at each depth. As they are supported on distributions, a renormalization is required. With the Wick renormalization, we carry out the construction of the Gibbs measures for ILW. We then prove that the Gibbs measures for ILW converge in total variation to that for the Benjamin-Ono equation (BO) in the deep-water limit. In the shallow-water regime, after applying a scaling transformation, we prove that, as depth tends to zero (shallow-water limit), the Gibbs measures for the scaled ILW converge weakly to that for the Korteweg-de Vries equation (KdV). We point out that this second result is of particular interest since the Gibbs measures for the scaled ILW and KdV are mutually singular (whereas the Gibbs measures for ILW and BO are equivalent). We also discuss convergence of the associated dynamical problem.

Stochastic homogenization for jump process

Xin CHEN

Shanghai Jiao Tong University

We will introduce several results on stochastic homogenization for jump process, including the QIP (quenched invariance principle) for long range random walk in random conductance model, the stochastic homogenization for general jump process in periodic media, the QIP for stable-like random walk in balanced environment. The talk is based on a series of joint work with Marek Biskup, Zhen-qing Chen, Takashi Kumagai and Jian Wang.

Test the effects of high-dimensional covariates via aggregating cumulative covariances

Liping ZHU

Renmin University

In this talk I shall introduce how to test for the effects of high-dimensional covariates on the response. In many applications, different components of covariates usually exhibit various levels of variation, which is ubiquitous in high-dimensional data. To simultaneously accommodate such heteroscedasticity and high dimensionality, we propose a novel test based on an aggregation of the marginal cumulative covariances, requiring no prior information on the specific form of regression models. Our proposed test statistic is scale-invariant, tuning-free and convenient to implement. The asymptotic normality of the proposed statistic is established under the null hypothesis. We further study the asymptotic relative efficiency of our proposed test with respect to the state-of-art universal tests in two different settings: one is designed for high-dimensional linear model and the other is introduced in a completely model-free setting. A remarkable finding reveals that, thanks to the scale-invariant property, even under the high-dimensional linear models, our proposed test is asymptotically much more powerful than existing competitors for the covariates with heterogeneous variances while maintaining high efficiency for the homoscedastic ones.

Quantitative homogenization of interacting particle systems

Chenlin GU

Yau Mathematical Sciences Center, Tsinghua University

This talk presents that, for a class of interacting particle systems in continuous space, the finite-volume approximations of the bulk diffusion matrix converge at an algebraic rate. The models we consider are reversible with respect to the Poisson measures with constant density, and are of non-gradient type. This approach is inspired by recent progress in the quantitative homogenization of elliptic equations. Along the way, a modified Caccioppoli inequality and a multiscale Poincare inequality are developed, which are of independent interest. The talk is based on a joint work with Arianna Giunti and Jean-Christophe Mourrat.

KPZ scaling and Tracy-Widom distribution in statistical mechanics

Senya SHLOSMAN

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

I will explain the appearance of the KPZ scaling and Tracy-Widom distribution in the 2D and 3D Ising models. Based on a joint paper with Patrik Ferrari: The Airy2 process and the 3D Ising model, to appear in the Journal of Physics A: Mathematical and Theoretical.

Boundary Correspondence for Iso-geometric Analysis Based on Optimal Mass Transport

Falai CHEN

University Of Science And Technology Of China

Domain parameterization, i.e., constructing a map from a parameter domain to a computational domain, is a key step in isogeometric analysis. Before parameterizing the interior of the computational domain, the boundary correspondence between the parametric domain and the computational domain is required by most domain parameterization methods, and the quality of boundary correspondence has a great effect on the quality of subsequent interior parameterization and analysis. Previous methods manually fulfill this task in general, which is tedious and subject to trial and error. In this paper, we propose an automatic method to compute such a correspondence between the boundary of a parametric domain and the boundary of a computational domain based on the theory of optimal transport. We employ the curvature of the physical boundary as the measure to transport, and efficient algorithms are proposed to solve the optimal mass transport problem. Experimental examples demonstrate that the proposed approach can produce satisfactory results which are competitive with the manually designed method.

December 29th, Thursday

Title

Greg GALLOWAY

University of Miami

Abstract

Quantum Inequalities and Unitary Categorification

Linzhe HUANG

Yau Mathematical Sciences Center, Tsinghua University

In this talk, I will introduce our recent progress on quantum Fourier analysis. We unify and establish various quantum inequalities such as Young's inequality, reverse Young's inequality, (smooth) entropic convolution inequality, etc., on quantum symmetries. We prove a family of primary criteria for unitary categorification of fusion rings basis on the complete positivity of comultiplication, which are stronger than the Schur product criterion. Localized versions of primary criteria are applicable to check fusion rings with sparse data and could also be applied as analytic obstructions for principal graphs of subfactors.

Title

Po-Ning CHEN

University of California Riverside

Abstract

Nonlinear asymptotic stability of the hydrostatic equilibrium for some gaseous stars with vacuum free boundary

Yanlin WANG

Yau Mathematical Sciences Center, Tsinghua University

The global existence theory for some free boundary problems of gaseous stars have been investigated, including viscous polytropes and white dwarfs, and some inviscid polytropic stars with damping and solid core. The nonlinear asymptotic stability of the hydrostatic equilibrium for these stars have also been verified under some suitable assumptions.

Correlation functions in TsT/single trace TTbar correspondence

Hongfei SHU

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

The single trace TTbar deformed symmetric orbifold CFT is conjectured to correspond to the T-dual shift T-dual (TsT) deformation of the string theory on the $\mathrm{AdS}_3 \times M$ background. In this talk, we test this conjecture by comparing the two-point functions of the TsT side and the single trace TTbar side. This talk is based on the joint work with Wei Cui, Wei Song and Juntao Wang.

Oblique problems for nonlinear equations with augmented Hessian matrices

Feida JIANG

Southeast University

In this talk, we will study the elliptic theory for the oblique problems for a general kind of nonlinear equations with augmented Hessian matrices. When the operator is nondegenerate, the classical existence theory for the strictly regular case and the regular case will be discussed respectively. When the operator is degenerate, the theory for the strong solutions is established, where the viscosity theory for second-order pde is applied. This talk is based on a series of joint works (Oblique boundary value problems for augmented Hessian equations I, II, III) with Neil S. Trudinger.

The nonlinear stability of Kerr for small angular momentum

Jeremie SZEFTEL

Sorbonne Université

I will introduce the celebrated black hole stability conjecture according to which the Kerr family of metrics are stable as solutions to the Einstein vacuum equations of general relativity. I will then discuss the history of this problem, including a recent work on the resolution of the black hole stability conjecture for small angular momentum.

The Dirac–Klein-Gordon equations in two spatial dimensions

Zoe WYATT

King's College London

Semilinear wave equations in three spatial dimensions are well-studied, including blow-up examples and nonlinear conditions such as the null condition and the weak null condition. Turning to two spatial dimensions, and considering coupled wave, Klein-Gordon and/or Dirac PDEs, leads to several interesting open problems. In this talk I will discuss a recent result, in collaboration with Shijie Dong (SUSTech), concerning the Dirac–Klein-Gordon system in two spatial dimensions. We provide the first asymptotic stability result for this system and are able to weaken certain nonlinear conditions assumed in the dispersive PDE literature.

Rough solutions of the 3-D compressible Euler equations

Qian WANG

University of Oxford

I will talk about my work on the compressible Euler equations. We prove the local-in-time existence the solution of the compressible Euler equations in 3-D, for the Cauchy data of the velocity, density and vorticity $(v, \varrho, \omega) \in H^s \times H^s \times H^{s'}$, $2 < s' < s$. The result extends the sharp result of Smith-Tataru and Wang, established in the irrotational case, i.e $\omega = 0$, which is known to be optimal for $s > 2$. At the opposite extreme, in the incompressible case, i.e. with a constant density, the result is known to hold for $\omega \in H^s$, $s > 3/2$ and fails for $s \leq 3/2$, see the work of Bourgain-Li. It is thus natural to conjecture that the optimal result should be $(v, \varrho, \omega) \in H^s \times H^s \times H^{s'}$, $s > 2,\ s' > \frac{3}{2}$. We view our work as an important step in proving the conjecture. The main difficulty in establishing sharp well-posedness results for general compressible Euler flow is due to the highly nontrivial interaction between the sound waves, governed by quasilinear wave equations, and vorticity which is transported by the flow. To overcome this difficulty, we separate the dispersive part of sound wave from the transported part, and gain regularity significantly by exploiting the nonlinear structure of the system and the geometric structures of the acoustic spacetime.

Topological Approaches to Data and Complex Network

Jie WU

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

In this talk, we will give a brief introduction to topological data analysis (TDA) and its applications. Moreover, guided by the applications to higher-order interaction network, we will discuss some topological approaches to graphs and hypergraphs beyond TDA, including path homology introduced by S. T. Yau et al, and their generalizations such as hypergraph homology, which is an extension of simplicial homology. We will also report some of our recent works on the topic, including a frame work for introducing a new theory which unifies various aspects of topological approaches for data science, by being applicable both to point cloud data and to graph data, including networks beyond pairwise interactions.

Title

Shaoyuan WU

Jiangsu Normal University

Abstract

Mendelian randomization for causal inference on longitudinal traits

Yuehua CUI

Department of Statistics and Probability, Michigan State University

Mendelian randomization (MR) uses genetic variants as instrument variables to determine whether an observational association between an exposure and an outcome is causal. With the aid of millions of single nucleotide polymorphisms (SNPs), MR provides an alternative strategy for causal inference when the randomized controlled trail (the golden standard approach for causal inference) is unavailable or infeasible. In this talk, I will briefly introduce the MR framework which predominantly focuses on cross-sectional traits. Then, I will present some of our recent work on MR focusing on longitudinal traits of interest, motivated by a real study to evaluate the causal effect of hormone level on eating behavior in teen girls. We propose different MR models to investigate the causal effect of a longitudinal exposure on a longitudinal outcome. In one model, we assume that the current exposure affects the current outcome, which is further relaxed by a time-delayed causal effect model assuming that the past and/or current exposures could contribute to the current outcome. Any delayed causal effect can be determined through a variable selection algorithm. In addition of efficient estimation, we develop a global test to assess the existence of overall causal effect. The utility of the method is further illustrated via simulations and an application to an eating behavior study.

Combinatorial statistics: a common theme and a few examples

Jian DING

Peking University

In this talk, I will describe some recent progress on shotgun assembly problems and random graph matching problems. Through these examples, I wish to convey the flavor of the topic of combinatorial statistics, and why it calls for joint efforts from statisticians, probabilists, computer scientists and researchers from applied sciences. The talk is based on recent joint works with Hang Du, Shuyang Gong, Yiyang Jiang, Haoyu Liu and Heng Ma in various combinations.

Bulk universality and quantum unique ergodicity of random band matrices

Fan YANG (M)

Yau Mathematical Sciences Center, Tsinghua University

Consider a general class of random band matrices H on the d-dimensional lattice of linear size L. The entries of H are independent centered complex Gaussian random variables with variances s_{xy}, which have a banded profile so that s_{xy} is negligible if $|x-y|$ exceeds the band width W. In dimensions $d \geq 7$, assuming that $W \geq L^{\delta}$ for a small constant $\delta > 0$, we prove the deloclaization and quantum unique ergodicity (QUE) of the bulk eigenvectors of H. Furthermore, we prove the bulk universality of H under the condition $W \gg L^{95/(d+95)}$. In the talk, I will discuss a new idea for the proof of the bulk universality through QUE, which verifies the conjectured connection between QUE and bulk universality. The proof of QUE is based on a local law for the Green's function of H and a high-order T-expansion developed recently. Based on Joint work with Xu, Yau and Yin.

Phase Transition of eigenvalues in Non-Hermitian Random Matrix Theory

Dangzheng LIU

University of Science and Technology of China

Consider a random matrix of size N as an additive deformation of the complex Ginibre ensemble under a deterministic matrix X_0 with a finite rank, independent of N. When some eigenvalues of X_0 separate from the unit disk, outlier eigenvalues may appear asymptotically in the same locations, and their fluctuations exhibit surprising phenomena that highly depend on the Jordan canonical form of X_0. These findings are largely due to Benaych-Georges and Rochet, Bordenave and Capitaine, and Tao. When all eigenvalues of X_0 lie inside the unit disk, we prove that local eigenvalue statistics at the spectral edge form a new class of determinantal point processes, for which correlation kernels are characterized in terms of the repeated erfc integrals. This thus completes a non-Hermitian analogue of the BBP phase transition in Random Matrix Theory. This talk is based on joint work with Lu Zhang.

Title

Nima ARKANI-HAMED

Institute for Advanced Study

Abstract

Defects, branes and 3D lattice model

Junya YAGI

Yau Mathematical Sciences Center, Tsinghua University

The 6-vertex model is one of the most famous integrable 2D lattice models and appears in many different quantum field theories, such as 2D N=(2,2) gauge theories, 4D N=2 gauge theories and 4D Chern-Simons theory. Less known is that the 6-vertex model arises from an integrable 3D lattice model by reduction on a circle. In my previous work with Kevin Costello, we gave a unified understanding to the above-mentioned appearances of the 6-vertex model using branes and string dualities. In this talk, I will explain the construction of the 3D lattice model using branes in M-theory, emphasizing the role played by a structure of TQFT with defects and extra dimensions.

Systolic inequality on Riemannian manifold with bounded Ricci curvature

Zhifei ZHU

Yau Mathematical Sciences Center, Tsinghua University

In this talk, we show that the length of a shortest closed geodesic on a Riemannian manifold of dimension 4 with diameter D, volume v, and $|Ric|<3$ can be bounded by a function of v and D. In particular, this function can be explicitly computed if the manifold is Einstein. The proof of this result depends on a structural theorem proven by J. Cheeger and A. Naber. This is joint work with N. Wu.

Singular equivariant instantons and K3 metrics

Arnav TRIPATHY

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

It has been a longstanding open problem to explicitly determine Ricci-flat metrics on any (non-torus) compact manifolds. Recently, S. Kachru, M. Zimet, and I initiated a program to do so for K3 manifolds via a modular interpretation of K3s as moduli spaces of singular equivariant instantons on T^4. I'll explain this statement and indicate some of the new analytic tools necessary to understand the singular elliptic complex controlling the above gauge-theory problem as developed in joint work with A. Vasy and M. Zimet. Time permitting, I'll explain the application of the above program to enumerative algebraic geometry.

Title

Sergio CECOTTI

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

Abstract

Refinements of G_2 structures

Matthew MAGILL

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

Any given G_2 structure manifold admits a refinement of its structure group beyond that of the G_2 group: an almost contact metric 3-structure. In essence, this geometrically realizes the restriction of the tangent bundle's structure to $SU(2)$ inside G_2. In this talk, we will introduce these notions in more detail, discuss their moduli and highlight some connections to things of interest in geometry and physics. This will be based on 2101.12605.

Topological Defect Lines in 2D (Fermionic) CFTs

Fengjun XU

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

In this talk, we will talk about topological defect lines (TDLs) in two dimensional (conformal) theories and their roles in category symmetries, which generalize the notion of symmetries by including non-invertible elements. In particular, we will introduce their new features in 2d Fermionic conformal theories, as well as their strong constraints in the study of RG flows.

BMS field theories

Pengxiang HAO

Yau Mathematical Sciences Center, Tsinghua University

The BMS (Bondi-van der Burg-Metzner-Sachs) symmetry arises as the asymptotic symmetry of flat spacetime at null infinity. The 2d BMS field theories are a kind of non-relativistic quantum field theory equipped with the BMS_3 algebra. They serve as the candidates of the dual theory of flat holography and flat space chiral gravity in 3d. In this talk, I will report on our recent study on the BMS field theories, including the properties from the general consideration of symmetry algebra and representation, the appearance of the multiplets. We also calculate the global blocks and develop BMS bootstrap. Besides, we consider the detailed free models as the testing ground, solving them by canonical quantization, then organizing them in the language of BMS data. These theories feature novel properties on the primary multiplet, the staggered module and the induced module.

Missing Corner in the Sky: Massless Three-Point Celestial Amplitudes

Wenjie MA

Yanqi Lake Beijing Institute of Mathematical Sciences and Applications

We study three-point celestial amplitudes in Minkowski space for massless scalars, photons, gluons, and gravitons. The corresponding scattering amplitudes in the plane wave basis vanish for generic momenta due to momentum conservation. However, the delta function for the momentum conservation has support in the soft and colinear regions, and contributes to the Mellin and shadow integrals that give non-zero celestial amplitudes. We show that the amplitudes with the incoming (outgoing) particles in the (shadow) conformal basis take the standard form of correlators in two-dimensional conformal field theory. In particular, the three-point celestial gluon amplitudes take the form of a three-point function of a spin-one current with two spin-one primary operators, which strongly supports the relation between soft spinning particles and conserved currents. Moreover, the three-point celestial amplitudes of one graviton and two massless scalars take the form of a correlation function involving a primary operator of conformal weight one and spin two, whose level-one descendent is the supertranslation current.

MSW-type compactifications of 6d (1, 0) SCFTs on 4-manifolds

Wei CUI

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We study compactifications of 6d (1, 0) SCFTs, in particular those of conformal matter type, on Kahler 4-manifolds. We show how this can be realized via wrapping M5 branes on 4-cycles of non-compact Calabi-Yau fourfolds with ADE singularity in the fiber. Such compactifications lead to domain walls in 3d $N = 2$ theories which flow to 2d N = (0, 2) SCFTs. We compute the central charges of such 2d CFTs via 6d anomaly polynomials by employing a particular topological twist along the 4-manifold. Moreover, we study compactifications on non-compact 4-manifolds leading to coupled 3d-2d systems. We show how these can be glued together consistently to reproduce the central charge and anomaly polynomial obtained in the compact case. Lastly, we study concrete CFT proposals for some special cases. The talk is based on a recent paper arXiv:2211.06943.

Useful Information

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