

Algebraic Topology and Its Applications in Geometry and Physics



Tianyuan Mathematics Research Center

2026.03.29--2026.04.04, Kunming

Invited Speakers:

Pedram Hekmati (Auckland)

Xiaonan Ma (Nankai)

Tsuyoshi Kato (Kyoto)

Konrad Waldorf (Greifswald)

Stephan Klaus (Oberwolfach)

Weiping Zhang (Nankai)

Guchuan Li (PKU)

Zhengyi Zhou (AMSS)

Si Li (Tsinghua)

Chenchang Zhu (Göttingen)

Yuanchu Li (NUS)

Yifei Zhu (SUST)

Bo Liu (ECNU)

Foling Zou (AMSS)

Organizers:

Haibao Duan (AMSS), Fei Han (NUS), Ruizhi Huang (AMSS)

Conference Information

The conference “Algebraic Topology and Its Applications in Geometry and Physics” will be held at the Tianyuan Mathematics Research Center.

This conference aims to bring together leading researchers and young scholars working in algebraic topology, differential geometry, and mathematical physics. The focus is on recent advances in homotopy theory, index theory, higher structures, topological field theories, and their interactions with geometry and physics. By fostering communication among experts from diverse backgrounds, the conference seeks to promote the development of new ideas and collaborations, and to highlight the deep connections between topology, geometry, and modern theoretical physics.

Organizers

Haibao Duan (Academy of Mathematics and Systems Science, Chinese Academy of Sciences)

Fei Han (National University of Singapore)

Ruizhi Huang (Academy of Mathematics and Systems Science, Chinese Academy of Sciences)

Contact

Ruizhi Huang, huangrz@amss.ac.cn, 13269778022

Conference Schedule

March 30, 2026 (Monday)

07:30–09:00	Breakfast	
	Chair:	
09:00–09:45	Weiping Zhang <i>Chern Institute of Mathematics, Nankai University</i>	Geometry and topology of Spin^c manifolds
	Coffee Break	
	Chair:	
10:00–10:45	Xiaonan Ma <i>Nankai University</i>	Lambda ring structure in differential K-theory
	Coffee Break	
	Chair:	
11:00–11:45	Guchuan Li <i>Peking University</i>	An Analogue of the J-homomorphism in Topological Modular Forms
11:45–13:00	Lunch	
	Free Discussion	
17:30–19:00	Dinner	

March 31, 2026 (Tuesday)

07:30–09:00	Breakfast	
	Chair:	
09:00–09:45	Tsuyoshi Kato <i>Kyoto University</i>	Amenable vs nonamenable groups in covering geometry
	Coffee Break	
	Chair:	
10:00–10:45	Bo Liu <i>East China Normal University</i>	Differential K-theory and the localization formula for eta invariants
	Coffee Break	
	Chair:	
11:00–11:45	Yuanchu Li <i>National University of Singapore</i>	Differential Anderson Dual of Twisted Spin^c -Bordism and Twisted Anomaly Map

11:45–13:00	Lunch
	Free Discussion
17:30–19:00	Dinner

April 1, 2026 (Wednesday)

07:30–09:00	Breakfast
	Chair:
09:00–09:45	Stephan Klaus <i>Mathematisches Forschungsinstitut Oberwolfach</i> On homotopy type, differentials in Adams spectral sequence and simplicial group operations
	Coffee Break
	Chair:
10:00–10:45	Pedram Hekmati <i>University of Auckland</i> The eta invariant and Floer stable homotopy type
	Coffee Break
	Chair:
11:00–11:45	Zhengyi Zhou <i>Academy of Mathematics and Systems Science, Chinese Academy of Sciences</i> Algebraic planar torsion in contact manifolds
11:45–13:00	Lunch
	Free Discussion
17:30–19:00	Dinner

April 2, 2026 (Thursday)

07:30–09:00	Breakfast
	Chair:
09:00–09:45	Konrad Waldorf <i>University of Greifswald</i> Higher gauge theory
	Coffee Break
	Chair:
10:00–10:45	Yifei Zhu <i>Southern University of Science and Technology</i> Topological and geometric perspectives on non-Hermitian Hamiltonians
	Coffee Break

	Chair:
11:00–11:45	<p style="text-align: center;">Foling Zou <i>Academy of Mathematics and Systems Science, Chinese Academy of Sciences</i></p> <p style="text-align: right;">Equivariant Steenrod operations</p>
11:45–13:00	Lunch
	Free Discussion
17:30–19:00	Dinner

April 3, 2026 (Friday)

07:30–09:00	Breakfast
	Chair:
09:00–09:45	<p style="text-align: center;">Chenchang Zhu <i>University of Göttingen</i></p> <p style="text-align: right;">Weinstein’s category for shifted symplectic structures via groupoids</p>
	Coffee Break
	Chair:
10:00–10:45	<p style="text-align: center;">Si Li <i>Tsinghua University</i></p> <p style="text-align: right;">Holomorphic Quantum Field Theory</p>
11:45–13:00	Lunch
	Free Discussion
17:30–19:00	Dinner

Title and Abstract

March 30, 2026 (Monday)

Geometry and topology of Spin^c manifolds

Weiping Zhang

Chern Institute of Mathematics, Nankai University

We discuss some results concerning Spin^c manifolds.

Lambda ring structure in differential K-theory

Xiaonan Ma

Nankai University

In this talk, we will introduce the splitting principle for differential K-theory and construct a lambda ring structure on the differential K-ring. This structure enables a concrete construction of the Adams operations in differential K-theory introduced by Bunke.

An Analogue of the J-homomorphism in Topological Modular Forms

Guchuan Li

Peking University

The classical J-homomorphism connects the 8-periodic homotopy groups of real K-theory to the stable homotopy groups of spheres, yielding a direct summand known as the “image of J.” In this talk, we first survey recent advances that use topological modular forms to construct nontrivial elements in the primary stable homotopy groups of spheres modulo the image of J. We then introduce a construction of transfer maps for profinite groups, which allows the J-homomorphism to be interpreted as such a transfer in the chromatic height-1 localisation. This framework provides a systematic analogue of the J-homomorphism at all chromatic heights. At height 2 and primes $p > 3$, we show that this analogue detects elements that were first computed by Shimomura–Oka in the stable homotopy groups of spheres modulo the image of J. This is joint work in progress with Ningchuan Zhang.

March 31, 2026 (Tuesday)

Amenable vs nonamenable groups in covering geometry

Tsuyoshi Kato

Kyoto University

In this talk, I will explain some extreme natures of distribution of zeros of vector fields and fixed point sets of self maps on amenable or nonamenable covering spaces.

Differential K-theory and the localization formula for eta invariants

Bo Liu

East China Normal University

In this talk, we will explain how to establish a localization formula for equivariant eta invariants through the application of differential K-theory. The eta invariant, a refined spectral invariant originally introduced in the 1970s as the boundary contribution of the Atiyah-Patodi-Singer index theorem for compact manifolds with boundary, represents formally the difference between the number of positive and negative eigenvalues of the Dirac operator. Our main result establishes a localization formula that connects the equivariant eta invariant of a Spin^c manifold equipped with an S^1 action to the eta invariants on the fixed point sets of the action. This extends the classical Atiyah-Segal localization formula for equivariant indices to the more complex setting of spectral invariants, which are not computable locally and lack topological invariance. The construction proceeds through three key steps: First, we develop a pre- λ -ring structure in differential K-theory. Second, we prove a localization theorem in differential K-theory specifically for S^1 -actions. Finally, we apply an extension of Goette's comparison formula between two natural versions of equivariant eta invariants. If time permits, we will discuss recent extensions of this localization formula to equivariant Bismut-Cheeger eta forms using the Bunke-Schick model of differential K-theory. This work is joint with Xiaonan Ma.

Differential Anderson Dual of Twisted Spin^c -Bordism and Twisted Anomaly Map

Yuanchu Li

National University of Singapore

We construct differential models for degree-3 twisted Spin^c -bordism and its Anderson dual. Using the differential twisted Anderson dual as target, we define a twisted anomaly map from differential twisted K-theory. To connect our models with the geometric framework of the Atiyah-Singer index theory, we further present a gerbe-theoretic formulation in terms of bundle gerbes and gerbe modules. The desired twisted anomaly map is then constructed using the reduced eta-invariant of Dirac operators acting on Clifford modules determined by the twisted data, where the Atiyah-Patodi-Singer index theorem provides bordism invariance and variation identities. Conceptually, this anomaly map is expected to be related to the anomalies of twisted 1|1-dimensional supersymmetric field theories, in line with the perspectives of Stolz-Teichner and Freed-Hopkins on anomalies and invertible field theories.

April 1, 2026 (Wednesday)

On homotopy type, differentials in Adams spectral sequence and simplicial group operations

Stephan Klaus

Mathematisches Forschungsinstitut Oberwolfach

We give a short report on our results concerning the homotopy type of finite spectra/spaces, differentials in the (stable/unstable) Adams spectral sequence and their explicit combinatorial description by certain simplicial group operations. We start with our old result (2001) on homotopy type that the image of the Hurewicz map is given by B -homomorphisms in cohomology, where B denotes the set of all higher cohomology operations (locally at a prime p). This follows from a theorem of Maunder that differentials in the Adams spectral sequence are given by elements in B . As a corollary, the homotopy type is fixed by cohomology as a B -module. Without an effective description of the differentials and their action on cohomology, this is quite a theoretical result. Recently we have found an explicit combinatorial description of the differentials by certain simplicial group operations. Unfortunately the combinatorial formulas, although being very explicit, grow exponentially by dimension.

The eta invariant and Floer stable homotopy type

Pedram Hekmati

University of Auckland

Seiberg-Witten gauge theory is a central tool in low-dimensional topology. In three dimensions, its invariants can be enhanced to an equivariant stable homotopy type, which refines and strengthens traditional Floer homology. The construction uses the APS index theorem and the eta invariant to offset the dependence on choices. In this talk, I will give a brief overview of this construction, describe the modifications required to incorporate finite group actions, and present some applications.

Algebraic planar torsion in contact manifolds

Zhengyi Zhou

Academy of Mathematics and Systems Science, Chinese Academy of Sciences

This talk explains how functoriality with respect to Maurer-Cartan deformations arises in symplectic field theory. Using these structures, I will establish three main results: (1) for any integer $k > 0$, there exist infinitely many contact manifolds of dimensions at least 5 with algebraic planar torsion k that are weakly fillable but not strongly fillable, confirming a conjecture of Latschev and Wendl; (2) tight contact manifolds that are not weakly fillable abound in all dimensions at least 5; and (3) all known contact manifolds in dimension five and higher that fail to be weakly or strongly fillable are observed to possess algebraic planar torsion.

April 2, 2026 (Thursday)

Higher gauge theory

Konrad Waldorf

University of Greifswald

This talk provides an introduction to higher gauge theory. We begin with the physical motivation from B-fields in string theory, and we introduce key mathematical structures such as categorical groups and bundle gerbes. We discuss some conceptual challenges that arise when extending familiar notions like curvature and holonomy to higher dimensions, and conclude with an overview of recent developments.

Topological and geometric perspectives on non-Hermitian Hamiltonians

Yifei Zhu

Southern University of Science and Technology

Non-Hermitian physics has become an emerging area of research in condensed matter physics, with far-reaching applications to materials science. Resulting from symmetry beyond classical Hermiticity, complexity of the topological structure in such quantum mechanical systems poses challenges to mathematical modeling while affording unconventional physical phenomena. In this talk, I'll report on joint work with physicists Hongwei Jia, Jing Hu, C. T. Chan et al., in which we investigate stratified singularity in the moduli spaces of such systems using intersection homology for homotopical classifications. I'll then explain joint work in progress with Zhou Fang, Chenlu Huang, Qingrui Qu, Wenhui Yang, and Zhiwang Yu towards an understanding of hyperbolic geometry therein, through Higgs bundles modeling eigenbundles, and Minkowski light-cones modeling exceptional surfaces, with examples.

Equivariant Steenrod operations

Foling Zou

Academy of Mathematics and Systems Science, Chinese Academy of Sciences

Representation graded Bredon G -equivariant cohomology theories are represented by genuine G -spectra. We introduce the concept of R -Eulerian sequences for an equivariant commutative ring spectra R . Each R -Eulerian sequence corresponds to a stable R -cohomology operation. We apply our theory to equivariant ordinary cohomology to produce genuine equivariant lifts of the classical Steenrod operations for all finite groups. This is joint work with Prasit Bhattacharya, Alex Waugh and Mingcong Zeng.

April 3, 2026 (Friday)

Weinstein's category for shifted symplectic structures via groupoids

Under the motto that “everything is Lagrangian”, Alan Weinstein proposed a category whose objects are symplectic manifolds and whose morphisms are Lagrangian correspondences. As Poisson geometry has developed over the past decades—motivated largely by classical mechanics—additional structures such as Poisson, Dirac, and Courant have emerged. Safronov, drawing on the shifted symplectic structures of Pantev–Toën–Vaquié–Vezzosi (PTVV), places these geometric structures into a unified framework by viewing them as symplectic structures of various shifts. This viewpoint also connects naturally to index theory: 1-shifted symplectic geometry includes quasi-Hamiltonian spaces, and their quantization, through work of Meinrenken together with the Freed–Hopkins–Teleman theorem, takes values in twisted equivariant K-theory/K-homology and the Verlinde ring. Thus shifted symplectic geometry provides not only a conceptual home for Poisson-type structures, but also a bridge to K-theoretic quantization.

Calaque–Haugseeng–Scheinbauer constructed a TFT with target a version of such Weinstein category for shifted symplectic structures using higher derived stacks in the sense of Toën–Vezzosi. While the language of stacks is intrinsic, it remains rather implicit for differential geometers and therefore difficult to use for concrete calculations. Pridham approaches higher derived stacks via presentations by groupoids, a setting far more familiar to researchers in differential geometry, dynamical systems, and noncommutative geometry.

Inspired by Pridham’s approach, we construct a Weinstein category for shifted symplectic structures using higher derived Lie groupoids. However, the topology we use for derived manifolds differs from that of Toën–Vezzosi and Pridham: we work with fibrations admitting local sections, which allow us to treat the odd line and cotangent groupoids—key examples in Poisson geometry.

We prove that when intersections are transversal in a higher derived sense, the composition of Lagrangian correspondences remains Lagrangian. As always, there is technical difficulty when intersection is not transversal. Broadly, two methods are available: (1) perturbation, as in the Fukaya category, which yields explicit results but requires delicate analysis; or (2) (fibrant) replacement, as in PTVV, which is conceptual but requires a homotopical framework and typically leaves explicit fibrant replacements to be worked out.

We adopt the second method and build an iCFO (incomplete category of fibrant objects) for derived higher Lie groupoids and provide explicit fibrant replacements using a collection of tubular neighborhood theorems: Weinstein’s Lagrangian tubular neighborhood theorem, and the Hoyó–Fernandes version for Lie groupoids via the Crainic–Fernandes–Torres PMCT program. As applications, we use Calaque–Safronov’s trick, then singular symplectic reduction, quasi-symplectic reduction, and Lu–Weinstein reduction, all appear as shifted symplectic derived Lie groupoids.

Holomorphic Quantum Field Theory

Si Li

Tsinghua University

We discuss recent developments on ultra-violet finiteness of holomorphic QFT. We present several applications, including elliptic trace formula for chiral deformations of 2d CFT, and holomorphic Chern-Simons theory in the large N limit.

List of Participants

Xiaoyang Chen	Tongji University
Geyang Dai	National University of Singapore
Haibao Duan	Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Huitao Feng	Nankai University
Jianquan Ge	Beijing Normal University
Fei Han	National University of Singapore
Pedram Hekmati	University of Auckland
Ruizhi Huang	Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Yi Jiang	Capital Normal University
Tsuyoshi Kato	Kyoto University
Stephan Klaus	Mathematisches Forschungsinstitut Oberwolfach
Guchuan Li	Peking University
Pengcheng Li	Great Bay University
Si Li	Tsinghua University
Yuanchu Li	National University of Singapore
Bingxiao Liu	Great Bay University
Bo Liu	East China Normal University
Yunze Lu	Fudan University
Zhi Lv	Fudan University
Xiaonan Ma	Nankai University
Chao Qian	Beijing Institute of Technology
Wen Shen	Wenzhou University
Yang Su	Chinese Academy of Sciences
Zheyuan Wan	Yanqi Lake Beijing Institute of Mathematical Sciences and Applications
Konrad Waldorf	University of Greifswald
Xin Wang	Shandong University
Wenjiao Yan	Beijing Normal University
Huijun Yang	Henan University
Jianqing Yu	University of Science and Technology of China
Weiping Zhang	Nankai University
Zhengyi Zhou	Academy of Mathematics and Systems Science, Chinese Academy of Sciences
Chenchang Zhu	University of Göttingen
Yifei Zhu	Southern University of Science and Technology
Foling Zou	Chinese Academy of Sciences

About the Center

The Tianyuan Mathematics Research Center (hereinafter referred to as “the Center”) was established in July 2023. It is an international platform for research and exchange in mathematics and interdisciplinary sciences, jointly supported by programs of the Tianyuan Fund of the National Natural Science Foundation of China and the National Development and Reform Commission. The Center is affiliated with the Academy of Mathematics and Systems Science, Chinese Academy of Sciences.

Location

The Center is located in the Chai Shitan Reservoir area, Yiliang County, Kunming, Yunnan Province, within a National Class I Public Welfare Forest. It is surrounded by mountains on three sides and faces water on one side, offering a scenic environment and pleasant climate.

- Altitude: 1,700 meters
- Distance to Kunming Changshui International Airport: ~90 km (about 1.5 hours by car)
- Distance to Stone Forest Scenic Area: 30 km
- Distance to Jiuxiang Scenic Area: 20 km

Campus Overview

- Total land area: ~27,000 m²
- Green area: ~19,000 m²
- Total building area: ~6,000 m²

The Center consists of three main two-story buildings:

- Research Building
- Experts' Residence Building
- Logistics and Support Building

Accommodation (Experts' Residence Building)

The residence building includes 56 rooms:

- 44 single rooms (1.5 m bed)
- 11 standard twin rooms (1.2 m beds)
- 1 accessible single room (1.2 m bed)

All rooms are equipped with private bathrooms and showers.

Facilities include:

- 4 staircases and 2 elevators
- Meditation pavilion in the inner courtyard
- Public restrooms, linen room, and laundry room
- Self-service coffee machine (2nd floor lounge area)
- Self-service laundry room with washer-dryer (2nd floor, southwest corner)

Research Facilities (Research Building)

- Large lecture hall (capacity: 100), equipped with HD LED screen and sliding blackboards
- 1 medium-sized conference room (80 m², HD LED screen)
- 4 small meeting rooms (35 m², HD short-throw projector and blackboards)
- 21 seminar/work rooms (20 m² each)
- 1 library reading room
- 1 café

Dining and Services (Logistics and Support Building)

- Activity room / staff fitness room ("Staff Home"), ~50 m²
- 7 staff dormitory rooms (~20 m² each)
- Dining hall (~200 m²), accommodating up to 60 people simultaneously

Safety and Infrastructure

The Center is enclosed by perimeter walls and equipped with:

- Guard room
- Fire water tank and pump room
- Reclaimed water treatment station
- Security monitoring system







