



清华大学 丘成桐数学科学中心
Yau Mathematical Sciences Center, Tsinghua University



Postdoc Workshop VII



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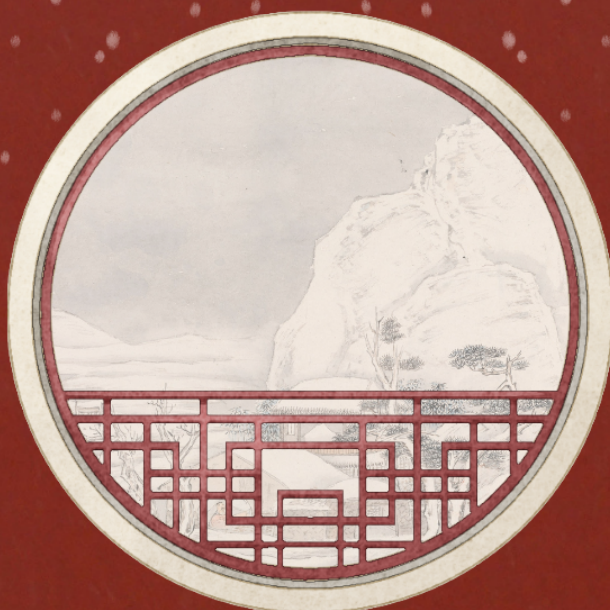
邵钰菓

唐乾

徐识

杨杰

左浩



Nov. 15-16
C548, Shuangqing



Contents

About	3
Postdoc Workshop VII 2025	3
Date	3
Venue	3
Zoom	3
Purpose	3
Scientific and Organizing Committee	3
Support Fundings	3
Contact information	3
Timetable	4
November 15, Saturday	4
November 16, Sunday	5
List of Abstracts	6
November 15, Saturday	6
November 16, Sunday	11
Useful Information	16
A Guide to Shuangqing Complex Building A	16
Previous Workshop	17

Postdoc Workshop VII 2025

Date

November 15-16, 2025

Venue

清华大学双清综合楼C548
Room C548, Shuangqing Complex Building, Tsinghua University

Zoom

Meeting ID: 892 226 4912
Password: YMSC

Purpose

Promote interaction and communication among postdocs and researchers.

Scientific and Organizing Committee

清华大学丘成桐数学科学中心博士后工作组

Support Fundings

清华大学丘成桐数学科学中心博士后活动经费
Funds for Postdoc Academic Activities, YMSC, Tsinghua University

Contact information

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Timetable

November 15, Saturday

Time	Welcome to Tsinghua	
9:40 - 9:50	丘成桐 Shing-Tung Yau	Opening
Chair: Mao Sheng		
9:50 - 10:15	Minseong Kwon	Sphericity of spaces of conics on rational homogeneous spaces
10:15 - 10:35	Break and Group Photo	
10:35 - 11:00	林小进 Xiaojin Lin	Galois-Categorification of Uniformization
11:00 - 11:25	杨杰 Jie Yang	On 2-adic integral models of some Shimura varieties
11:25 - 11:50	Angel Toledo	Deformation of monoidal dg-categories
Lunch		
Chair: Junpeng Jiao		
13:30 - 13:55	刘核旭 Hexu Liu	An Extension Theorem for Varieties with McKernan-type Fibration Structure and its applications for varieties with large canonical volumes
13:55 - 14:20	柳宇翔 Yuxiang Liu	The rigidity problem in rational homogeneous spaces
14:20 - 14:45	左浩 Hao Zuo	Yau algebras arising from two-dimensional rational hypersurface singularities
14:45 - 15:10	毛盛开 Shengkai Mao	Arithmetic compactifications of integral models of Shimura varieties
15:10 - 15:30	Break	
15:30 - 15:55	徐识 Shi Xu	The Double Covering of a Foliated Surface and Its Slope
15:55 - 16:20	Bishal Deb	Coefficientwise total positivity of Hankel matrices in counting problems
16:20 - 16:45	刘瑾 Jin Liu	Rural Income Increase Effect and Inequality Challenges of Public Data Openness
16:45 - 17:10	邵钰菓 Yuguo Shao	Diagnosing Quantum Circuits: Noise Robustness, Trainability, and Expressibility
Dinner		

November 16, Sunday

Time	Welcome to Tsinghua	
Chair: Cheng Zhang		
9:30 - 9:55	牛唯喆 Weizhe Niu	Mapping class groups of 4-manifolds via the Budney-Gabai invariants
9:55 - 10:20	Chun-Hao Hank Chen	A target for ribbon 2-functors
10:20 - 10:40	Break	
10:40 - 11:05	Shanon Rubin	Characterizing fibrant diagrams over graphic quivers: applications to homotopy limits and symplectic surfaces
11:05 - 11:30	崔千顺 Qianshun Cui	Hypersurfaces of $\mathbb{S}^2 \times \mathbb{S}^2$ and $\mathbb{H}^2 \times \mathbb{H}^2$ with recurrent Ricci tensor
11:30 - 11:55	Choudhury Diptaishik	Measured foliations at infinity of quasi Fuchsian manifolds
Lunch		
Chair: Hans Emil Oscar Mickelin		
13:30 - 13:55	Grigory Papayanov	Rational homotopy theory of manifold complements and Smith ideals
13:55 - 14:20	Anton Iliashenko	Hyperbolicity and Schwarz Lemmas in Calibrated Geometry
14:20 - 14:45	苗淳瑞 Borui Miao	Zero-energy Edge States of Tight-Binding Models for Generalized Honeycomb-Structured Materials
14:45 - 15:05	Break	
15:05 - 15:30	阮钰泽 Yuze Ruan	On the $\mathbb{Z}/2\mathbb{Z}$ Permutation Gauging of Modular Fusion Categories
15:30 - 15:55	Boudhayan Paul	Holographic entanglement negativity for disjoint subsystems in $\text{AdS}_{d+1}/\text{CFT}_d$
15:55 - 16:20	唐乾 Qian Tang	Stokes Matrices and Quantum Groups
16:20 - 16:45	Mehari Fentahun Endalew	Enhanced Heat and Mass Transport in Ionized Hybrid Nanofluids through a Porous Medium
Dinner		

List of Abstracts

November 15, Saturday

Sphericity of spaces of conics on rational homogeneous spaces

Minseong Kwon

MCM

Rational curves play an important role in the study of Fano varieties. Rational homogeneous spaces are well-known examples of Fano varieties, and their spaces of lines have been described by Tits geometry. Namely, for a rational homogeneous space X of Picard rank 1, the space of lines on X is homogeneous if and only if it is associated to a long simple root. In this talk, I will discuss the space of conics on X . The main result is that the space of conics on X is spherical if and only if it is associated to a long simple root. This talk is based on a joint work with Nicolas Perrin.

Galois-Categorification of Uniformization

林小进 **Xiaojin Lin**

YMSC

We prove that the classical Uniformization Theorem can be lifted to an equivalence of Galois categories. Concretely, we establish an isomorphism between the category of hyperbolic orbicurves and the category of Fuchsian lattices. Using parahoric theory and the non-abelian Hodge correspondence, we provide a systematic construction of opers, which allows us to promote this geometric equivalence to a Galois-theoretic one. As a direct application, we derive canonical Fuchsian group presentations for arithmetic Galois groups, creating a new link between the arithmetic of function fields and geometric group theory.

On 2-adic integral models of some Shimura varieties

杨杰 *Jie Yang*

YMSC

We construct integral models over $p=2$ for some Shimura varieties of abelian type with parahoric level structure, extending the previous work of Kim-Madapusi, and Kisin-Pappas-Zhou. As a corollary, we prove that these integral models are flat normal schemes over the p -adic integers, and their special fibers are reduced with each irreducible component being normal and Cohen-Macaulay.

Deformation of monoidal dg-categories

Angel Toledo

BIMSA

Given a monoidal dg-category we will propose a chain complex which controls the deformation theory of both the monoidal category structure and the underlying $\mathbb{R}$ -linear structure of Hom-complexes, and the compatibility between these. The resulting cohomology groups are a mix of Hochschild and Davydov-Yetter cohomology. I will present a number of concrete examples coming from algebra and algebraic geometry. This is joint work with Slava Pimenov.

An Extension Theorem for Varieties with McKernan-type Fibration Structure and its applications for varieties with large canonical volumes

刘核旭 *Hexu Liu*

YMSC

McKernan-type fibration is a useful tool for studying effective birationality problems in explicit birational geometry. In this talk, I will briefly outline the structure of McKernan-type fibrations and present an extension theorem for varieties endowed with such a structure. As an application, I provide a result about canonical stability indices for varieties with sufficiently large canonical volumes. I will also present several applications of the theorem in low-dimensional cases.

The rigidity problem in rational homogeneous spaces

柳宇翔 *Yuxiang Liu*

BIMSA

A Schubert class is called rigid if it can only be represented by Schubert varieties. In this talk, I will discuss the classification problem of rigid Schubert classes, together with some of variations and generalizations.

Yau algebras arising from two-dimensional rational hypersurface singularities

左浩 *Hao Zuo*

BIMSA

This talk concerns Yau algebras associated with two-dimensional rational hypersurface singularities. Since the infinitesimal deformation of a Lie algebra is controlled by its cohomology, we study the cohomology groups of these Yau algebras to understand their deformation behavior. In particular, we describe when such algebras are rigid and when non-trivial infinitesimal deformations appear.

Arithmetic compactifications of integral models of Shimura varieties

毛盛开 *Shengkai Mao*

MCM

Shimura varieties can be interpreted, in a broad sense, as moduli spaces of motives endowed with additional structures. We study their integral models together with their toroidal compactifications. Pappas and Rapoport showed that integral models are uniquely characterized by the existence of extensions of shtukas, along with certain prescribed local properties. In this talk, we extend this framework to the setting of toroidal compactifications and describe how the associated shtukas degenerate along the boundary. This is ongoing joint work with Peihang Wu.

The Double Covering of a Foliated Surface and Its Slope

徐识 *Shi Xu*

YMSC

In this talk, we construct a canonical resolution of double coverings of foliated surfaces and provide a concrete formula for c_1^2 , c_2 and χ of the double foliated surface. During the computation, we also establish a theorem on the Zariski decomposition of an adjoint divisor of type $K_{\mathcal{F}} + \Delta$, which generalizes McQuillan's theorem in the case $\Delta = 0$. We then prove that the slope of double foliated surfaces of general type is at least 4 if the original foliation satisfies $c_1^2 \geq 4\chi$ and the ramification divisor avoids the set of saddle-nodes. Additionally, we provide examples of transcendental double foliated surfaces with a slope of 12/7. This is joint work with Jun Lu, Xin Lv, and Shengli Tan.

Coefficientwise total positivity of Hankel matrices in counting problems

Bishal Deb

YMSC

Various sequences arising throughout enumerative combinatorics, and other fields of mathematics, seem to be Stieltjes moment sequences. This talk will begin with a quick introduction to Stieltjes moment sequences and their characterisation in terms of totally positive Hankel matrices, and continued fractions. We will then upgrade from sequences of numbers to sequences of polynomials, and introduce coefficientwise total positivity. We will then state some results, and various conjectures. Finally, if time permits, we will look at one of our recent results: the coefficientwise Hankel total positivity of Laguerre polynomials.

Rural Income Increase Effect and Inequality Challenges of Public Data Openness

刘瑾 *Jin Liu*

BIMSA

Public data openness (PDO) is globally regarded as a catalyst for economic growth. However, rigorous empirical evidence on its income increase effect and inclusive effect for vulnerable populations remains scarce. This study leverages a quasi-natural experiment arising from China's staggered rollout of PDO platforms at the municipal level. Using a panel dataset of 2003 counties spanning 2000-2022 and a staggered difference-in-differences (DID) approach, we identify the impact of PDO policy on rural residents' income (RI). Our findings indicate that this policy significantly boosts RI, an effect that operates primarily through two channels: stimulating agricultural innovation and entrepreneurship, and fostering rural financial development. Nevertheless, this income increase effect is accompanied by a significant inequality challenge: while boosting RI, the policy simultaneously widens the absolute urban-rural income gap (URGAP). Furthermore, the policy's effect exhibits substantial heterogeneity, with the income gains being particularly pronounced in the central and eastern regions, and in regions with lower government service efficiency. A case study suggests that a urban bias and a compliance tendency in data supply may be a critical factor contributing to the widening URGAP. Crucially, we find that the income increase effect is significantly amplified when data openness initiatives are devolved from the municipal to the county level. These results caution that the promise of inclusivity associated with digital technologies and data elements is not automatically realized. While unlocking potential dividends, policymakers must be vigilant against the creation of new divides.

Diagnosing Quantum Circuits: Noise Robustness, Trainability, and Expressibility

邵钰菓 *Yuguo Shao*

YMSC

Parameterized quantum circuits are central to near-term quantum algorithms, and serve as the foundation for many quantum machine learning frameworks, which should be robust to noise, maintain trainability, and exhibit sufficient expressibility. Here we introduce 2MC-OBPPP, a polynomial-time classical estimator that quantifies the three aforementioned diagnostics for a given parameterized quantum circuit. As a demonstration of the power of our approach, we show that moderate amplitude damping noise can reduce the severity of vanishing gradients, but at the cost of lowered expressibility. In particular, our approach can yield a spatiotemporal "noise-hotspot" map that pinpoints the most noise-sensitive qubits/gates in parameterized quantum circuits. Applying this map to a specific circuit, we show that implementing interventions on fewer than 2% of the qubits is sufficient to mitigate up to 90% of the errors. Therefore, 2MC-OBPPP is not only an efficient, hardware-independent tool for pre-execution circuit evaluation but also enables targeted strategies that significantly reduce the cost of noise suppression.

November 16, Sunday

Mapping class groups of 4-manifolds via the Budney-Gabai invariants

牛唯喆 *Weizhe Niu*

YMSC

According to the work of Budney-Gabai, the mapping class group of $S^1 \times D^3$ is infinitely generated. Their construction is based on a special class of diffeomorphism known as barbell diffeomorphism. They define a rational homotopy invariant and use it to detect an infinite sequence of linearly independent barbell diffeomorphisms. In this talk, I will review their construction and discuss some extensions of their results, and introduce an adaptation of their approach to study the mapping class group of the boundary-connected sums of $S^1 \times D^3$.

A target for ribbon 2-functors

Chun-Hao Hank Chen

BIMSA

Procedures for producing 3d topological invariants from algebraic categorical data are well-known; they now come under the name of (3d) "topological quantum field theories" (TQFTs). To lift them to higher-dimensions, one performs a categorification, but many unknowns still plague us. In particular, the key notion of a ribbon tensor 2-category is a central topic of recent research. In this talk, I will introduce an approach to this problem inspired from derived higher-gauge theory in 4-dimensions (see 2501.06486). The strategy is to systematically examine the various structures induced on the 2-category of 2-representations of a so-called "cobraided dagger Hopf category". By walking through the interaction of the braiding with the different levels of duality, we can algebraically and geometrically tease out properties of the 2-ribbon structure necessary for describing framed invariants of knots and surfaces in 4-space. This is based on my recent work arxiv:2501.08041.

Characterizing fibrant diagrams over graphic quivers: applications to homotopy limits and symplectic surfaces

Shanon Rubin

YMSC

In symplectic geometry, a Weinstein surface W can be understood by combinatorial data on its skeleton, which is generically a finite trivalent graph G . Motivated by the microlocal theory of sheaves, there is a naturally associated diagram D of differential-graded categories, defined over the quiver which replaces each edge of G by a cospan. We call such quivers 'graphic'. After adding in appropriate homological shifts, the homotopy limit of D yields an invariant of W , so we are motivated to find explicit presentations for these homotopy limits. Abstracting the story above, we fix an arbitrary graphic quiver Q . Given any model category M (above we had $M = \text{dg-categories}$) we consider M -valued diagrams over Q . I will present a combinatorial characterization of all such diagrams D which are suitably 'fibrant,' which in particular implies that the homotopy limit of D is just its classical limit. Analogous to the calculation of derived functors in homological algebra, this yields an explicit formula for the homotopy limit of any diagram, fibrant or not. I will assume no background in symplectic geometry or abstract homotopy theory, emphasizing examples and ideas over full generality and technical definitions.

Hypersurfaces of $\mathbb{S}^2 \times \mathbb{S}^2$ and $\mathbb{H}^2 \times \mathbb{H}^2$ with recurrent Ricci tensor

崔千顺 **Qianshun Cui**

Department of Mathematical Sciences

We prove that a hypersurface in $\mathbb{S}^2 \times \mathbb{S}^2$ (resp. $\mathbb{H}^2 \times \mathbb{H}^2$) with recurrent Ricci tensor is either an open part of $\Gamma \times \mathbb{S}^2$ (resp. $\Gamma \times \mathbb{H}^2$) for a curve Γ in $\mathbb{S}^2$ (resp. $\mathbb{H}^2$), or a hypersurface with constant sectional curvature.

Measured foliations at infinity of quasi Fuchsian manifolds

Choudhury Diptaishik

YMSC

Let $(\lambda^+(M), \lambda^-(M))$ denote the pair of measured foliations at the boundary at infinity of a quasi-Fuchsian manifold M . We prove that $(\lambda^+(M), \lambda^-(M))$ is filling if M is close to being Fuchsian. We also show that given any filling pair (α_1, α_2) of measured foliations, and every small enough $t > 0$, the pair $(t\alpha_1, t\alpha_2)$ is realised as the pair of measured foliations at infinity of some quasi-Fuchsian manifold M . This answers questions of Schlenker near the Fuchsian locus.

Rational homotopy theory of manifold complements and Smith ideals

Grigory Papayanov

BIMSA

Additively, the cohomology of the complement of an orientable submanifold in a compact orientable manifold could be calculated with the help of the Gysin exact sequence. However, multiplication and higher cohomology operations could not be extracted from it. Indeed, there exist homotopy equivalent pairs (compact manifold, submanifold) with homotopy non-equivalent complements. Using the homotopy theory of so-called Smith ideals in dg-algebras we show that, if the inclusion of submanifold induces an injection on the rational homotopy groups, the rational cochain algebra of the complement is determined by the rational homotopy type of the pair. Joint work with A. Gorinov.

Hyperbolicity and Schwarz Lemmas in Calibrated Geometry

Anton Iliashenko

BIMSA

We will define new notions of hyperbolicity for a general Riemannian manifold equipped with a calibration, which generalize the notions of Kobayashi and Brody hyperbolicity from complex geometry. For this we introduce a decreasing Finsler pseudo-metric that specializes to the Kobayashi-Royden pseudo-metric in the Kahler case; and derive the generalization of the classical Schwarz Lemma but for Smith immersions. We will talk about how these notions of hyperbolicity relate to one another and will see some examples. This is joint work with Kyle Broder and Jesse Madnick.

Zero-energy Edge States of Tight-Binding Models for Generalized Honeycomb-Structured Materials

苗淳瑞 *Borui Miao*

YMSC

Generalized honeycomb-structured materials have received increasing attention due to their novel topological properties. In this article, we investigate zero-energy edge states in tight-binding models for such materials with two different interface configurations: type-I and type-II, which are analog to zigzag and armchair interfaces for the honeycomb structure. We obtain the necessary and sufficient conditions for the existence of such edge states and rigorously prove the existence of spin-like zero-energy edge states. More specifically, type-II interfaces support two zero-energy states exclusively between topologically distinct materials. For type-I interfaces, zero-energy edge states exist between both topologically distinct and identical materials when hopping coefficients satisfy specific constraints. We further prove that the two energy curves for edge states exhibit strict crossing. We numerically simulate the dynamics of edge state wave packets along bending interfaces, which agree with the topologically protected motion of spin-like edge states in physics.

On the $\mathbb{Z}/2\mathbb{Z}$ Permutation Gauging of Modular Fusion Categories

阮钰泽 *Yuze Ruan*

YMSC

It is well known that the representation category of a suitable conformal field theory (CFT) forms a modular fusion category (MFC). The converse problem—reconstructing a CFT from a given MFC—is referred to as the reconstruction program. If this program works, many constructions and results in CFT are expected to extend to the framework of MFCs. Among these constructions, the orbifold construction plays a fundamental role in CFT, and its categorical counterpart in MFCs is known as the gauging construction. In this talk, I will present a detailed construction of the $\mathbb{Z}/2\mathbb{Z}$ permutation gauging. In particular, I will discuss how the genus-zero data of the gauged MFC encodes higher-genus data of the original MFC, as well as its various applications within the categorical framework. If time permits, I will also discuss some progress and future directions concerning the $\mathbb{Z}/3\mathbb{Z}$ case and more general cyclic permutation gaugings.

Holographic entanglement negativity for disjoint subsystems in $\text{AdS}_{d+1}/\text{CFT}_d$

Boudhayan Paul

BIMSA

We propose a construction to compute the holographic entanglement negativity for bipartite mixed state configurations of two disjoint subsystems in higher dimensional conformal field theories (CFT_d s) dual to bulk AdS_{d+1} geometries. Our proposal follows from the corresponding $\text{AdS}_3/\text{CFT}_2$ scenario and involves an algebraic sum of the areas of bulk RT surfaces for certain combinations of subsystems. Utilizing our construction we compute the holographic entanglement negativity at the leading order through a perturbative expansion, for such bipartite mixed states of two disjoint subsystems with long rectangular strip geometries in CFT_d s dual to bulk pure AdS_{d+1} geometries and AdS_{d+1} -Schwarzschild black holes.

Stokes Matrices and Quantum Groups

唐乾 *Qian Tang*

Department of Mathematical Sciences

In this talk, I will introduce the concepts of Stokes matrices and their connection to the corresponding quantum groups. Furthermore, we discovered a class of algebroid structures behind the Stokes matrices, and established the relations between the quantum groups and the Goldman bracket. Based on joint work with Xiaomeng Xu.

Enhanced Heat and Mass Transport in Ionized Hybrid Nanofluids through a Porous Medium

Mehari Fentahun Endalew

BIMSA

This talk presents a numerical investigation of heat and mass transfer enhancement in an ionized hybrid nanofluid within a porous medium. We develop a model that incorporates modified thermal and molecular diffusion laws to capture nonlocal and relaxation phenomena, alongside the effects of Hall and ion-slip currents. Our numerical simulations, focused on a Copper–Alumina/propylene glycol hybrid nanofluid, demonstrate how the interplay between nonlinear diffusion, electromagnetic forces, and porous resistance governs the overall transport dynamics. The results provide valuable insights for optimizing thermal and mass transfer in advanced engineering applications.

Useful Information

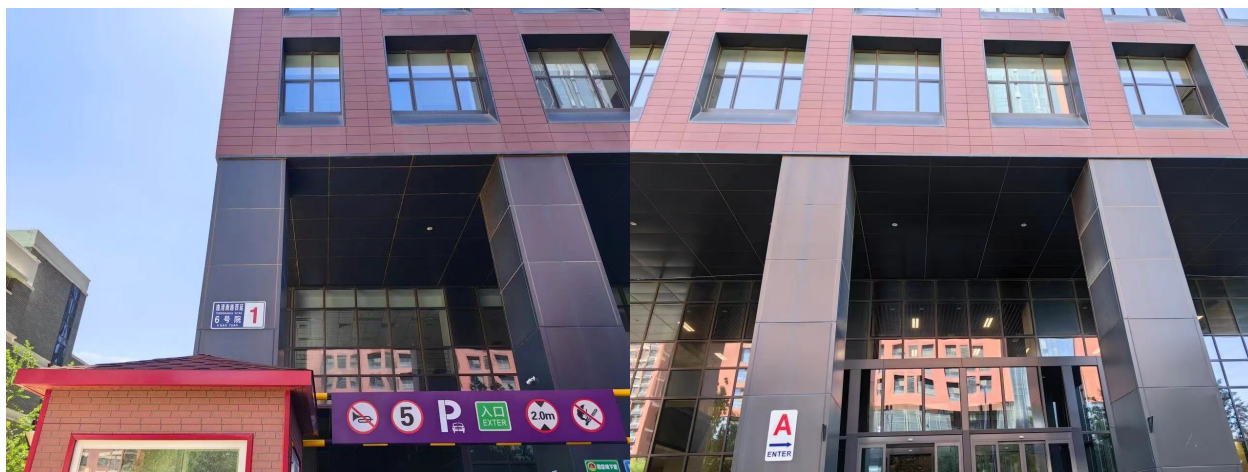
A Guide to Shuangqing Complex Building A



To commute between Jingzhai 静斋 and Shuangqing Building, one can go through the **East Gate** or **Northeast Gate**.



Then follow the red path to the Shuangqing Complex Building A (Yau Mathematics Science Center).



Exterior views of the building.

Address:

双清综合楼A座

北京市海淀区逸清南路西延6号院1号

Shuangqing Complex Building A

No. 1, Courtyard 6, West Extension of Yiqing South Road, Haidian District, Beijing

Remarks:

双清公寓马路对面、清华附小（双清校区）西侧

Across the street from Shuangqing Apartments, on the west side of Tsinghua University Primary School (Shuangqing Campus).

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Previous Workshop



Postdoc Workshop V 2025

