天元數學國際交流中心
Tianyuan Mathematics Research Center

复杂自由界面问题的建模与算法研讨会

Workshop on Modelling and Simulation of Complex Free Interface Problems

会议手册

Conference Program

召集人：

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2026 年 11 月 22 日—28 日

Nov. 22-28, 2026

中国 • 昆明

Kunming, China

天元数学国际交流中心简介

天元数学国际交流中心（以下简称“中心”）成立于2023年7月，由中国科学院、国家自然科学基金委员会、中国数学会、中国科学院数学与系统科学研究院，以及昆明市有关部门共同支持建设的数学与交叉科学交流机构。旨在搭建数学及其跨学科应用领域的学术交流平台，提升我国数学整体研究水平，成为国际一流的数学交流与合作研究中心。

中心位于昆明市宜良县柴石滩水库库区，三面环山、一面临水，环境优美，海拔约1700米。距长水国际机场约90公里（车程约1.5小时），距石林风景区约30公里，距九乡风景区约20公里。

中心总建筑面积约6000平方米，设有大报告厅（可容纳100人，配备高清LED屏）、中型会议室1间、小型会议室4间、研讨/工作室21间、图书阅览室1间、咖啡厅1间。专家楼配有56间宿舍及自助洗衣房、公共休息区等配套设施。

中心官方网站：http://tianyuan.amss.ac.cn/





Introduction to Tianyuan Mathematics Research Center （TYMRC）

The Tianyuan Mathematics Research Center (established in July 2023) is jointly supported by the Chinese Academy of Sciences, the National Natural Science Foundation of China, the Chinese Mathematical Society, the Academy of Mathematics and Systems Science of the Chinese Academy of Sciences, and relevant departments of Kunming City. It aims to build a platform for academic exchange in mathematics and interdisciplinary applications, enhance China's overall mathematical research level, and become a world-class center for mathematical exchange and collaborative research.

It is located in the national-level public welfare forest in the Chaishitan Reservoir area of Yiliang, Kunming, Yunnan Province, surrounded by mountains on three sides and facing water on one side. The center has a total land area of about 27,000 square meters, with three two-story main buildings, namely the Research Building, the Expert Building and the Logistics Building, which can accommodate nearly 200 people for academic activities, and are equipped with a library and reading room, a restaurant and a certain number of offices and guest rooms.

The center has a total construction area of approximately 6,000 square meters. It features a main lecture hall (capacity: 100 people, equipped with an HD LED screen), one medium-sized seminar room, four small meeting rooms, 21 seminar/workshop rooms, one library and reading room, and one café. The Expert Building is equipped with 56 guest rooms, as well as supporting facilities such as a self-service laundry room and a public lounge.

Official website: http://tianyuan.amss.ac.cn/

会议信息

一、研讨主题、内容及意义：

为促进复杂自由界面问题研究领域的国际学术交流与合作，我们申请于天元数学国际交流中心举办一场专题研讨会，聚焦于该领域的前沿建模方法与高效算法设计。自由界面问题广泛存在于材料科学、流体力学、生物数学、多物理场耦合系统、拓扑优化、图像分割等重要领域，其核心难点在于界面演化与整体动力学行为之间的强非线性相互作用，以及多尺度结构与复杂边界条件的数学处理。这类问题不仅具有深刻的数学问题，更在众多科学与工程应用中扮演着关键角色。本次会议将围绕相场模型、水平集方法、阈值动力学方法、界面追踪技术、自适应网格优化及高精度保结构数值格式等关键方向展开深入讨论，旨在梳理当前理论研究的瓶颈与计算实践中的挑战，探索跨学科方法的融合与创新。我们期望通过搭建这一高水平学术平台，汇聚国内外顶尖学者与优秀青年研究人员，就自由界面问题的建模、计算及应用等核心前沿问题进行系统而深入的探讨，共同推动该领域向更深入、更实用的方向发展。

会议的举办具有重要的科学意义与实践价值。一方面，通过对自由界面问题的数学建模与计算分析，能够为诸多自然科学与工程应用提供关键理论支撑与模拟工具。例如，在材料科学中的合金凝固过程中的晶界生长模拟；在流体力学中多相流界面不稳定性分析；在生物数学中细胞迁移与形态变化的建模，拓扑优化的可计算建模及高性能算法设计等，也极大拓展了自由界面问题研究的边界。

这些跨学科问题的深入探讨，不仅有助于揭示界面演化中的共性数理机制，也将促进不同学科领域在方法论层面的相互借鉴与协同创新。

另一方面，此类问题驱动的基础算法发展，如适用于复杂几何与动态界面的高性能计算方法，也将反哺计算数学本身，推动偏微分方程数值解、科学计算与软件集成等方向的进步。自由界面问题通常伴随几何奇异性、大变形、拓扑变化等挑战，传统数值方法往往难以兼顾效率与精度。因此，发展新型自适应网格技术、高分辨率界面捕捉格式、结构保持型离散方法等，已成为计算数学研究的前沿热点。通过本次会议，我们希望能够系统总结现有数值方法的优势与局限，促进计算数学与计算机科学、工程应用之间的深度融合，为复杂系统数值模拟提供更可靠、更高效的工具支撑。

二、活动日程：

报到：2026 年 11 月 22 日

报告：2026 年 11 月 23 日至 11 月 27 日

离会：2026 年 11 月 28 日

地点：天元数学国际交流中心（云南省昆明市宜良县柴石滩水库）

三、相关事项：

1. 本次研讨会得到天元数学国际交流中心资助，参会人员的住宿及餐饮由中心承担，其余费用（含往返交通费）由参会人员自理。
2. 中心统一安排往返昆明高铁站/长水机场及昆明市区的接送服务。请及时登录项目管理系统（http://tianyuanpm.amss.ac.cn/）登记行

程信息。

3. 中心距离医院较远，建议访客适当随时携带一些必备药品。

4. **会议联系人：**

王东（香港中文大学（深圳））：电话 18852840549

Conference Information

I. Seminar Theme, Content, and Significance：

To promote international academic exchange and collaboration on complex free-boundary problems, we propose to organize a thematic workshop at the Tianyuan Mathematical International Center, focusing on cutting-edge modeling approaches and efficient algorithm design. Free-boundary problems arise in many important areas, including materials science, fluid mechanics, biomathematics, multiphysics systems, topology optimization, and image segmentation. Their central challenges lie in the strongly nonlinear interactions between interface evolution and the dynamics of the overall system, as well as the mathematical treatment of multiscale structures and complex boundary conditions. These problems raise profound mathematical questions and play a pivotal role in numerous scientific and engineering applications. The workshop will feature in-depth discussions of key topics, including phase-field models, level-set methods, threshold dynamics methods, interface tracking techniques, adaptive mesh optimization, and high-order structure-preserving numerical schemes. It aims to identify bottlenecks in current theoretical research and challenges in computational practice, while exploring the integration and innovation of interdisciplinary approaches. By establishing this high-level academic platform, we hope to bring together leading scholars and outstanding early-career researchers from China and abroad for systematic and in-depth discussions of frontier issues in the modeling, computation, and application of free-boundary problems, advancing both fundamental understanding and practical applications.

The workshop will have substantial scientific significance and practical value. On the one hand, mathematical modeling and computational analysis of free-boundary problems provide essential theoretical foundations and simulation tools for a broad range of scientific and engineering applications. Examples include simulating grain-boundary growth during alloy solidification in materials science, analyzing interfacial instabilities in multiphase flows in fluid mechanics, modeling cell migration and morphological changes in biomathematics, and developing computationally tractable models and high-

performance algorithms for topology optimization. These applications have also greatly broadened the scope of free-boundary research. In-depth investigation of such interdisciplinary problems will help uncover common mathematical and physical mechanisms underlying interface evolution, while fostering methodological exchange and collaborative innovation across disciplines.

On the other hand, the development of fundamental algorithms driven by these problems—such as high-performance computational methods for complex geometries and evolving interfaces—will, in turn, advance computational mathematics itself, particularly in the numerical solution of partial differential equations, scientific computing, and software integration. Free-boundary problems often involve geometric singularities, large deformations, and topological changes, making it difficult for conventional numerical methods to achieve both efficiency and accuracy. Consequently, novel adaptive mesh techniques, high-resolution interface-capturing schemes, and structure-preserving discretization methods have become major research frontiers in computational mathematics. Through this workshop, we aim to systematically assess the strengths and limitations of existing numerical methods, foster closer integration among computational mathematics, computer science, and engineering applications, and provide more reliable and efficient computational tools for the numerical simulation of complex systems.

II、Program Schedule：

Check-in: Nov. 22, 2026

Talks: Nov. 23-Nov. 27, 2026

Departure: Nov. 28, 2026

Venue: Tianyuan Mathematics Research Center (Chishitan Reservoir, Yiliang County, Kunming, Yunnan Province)

III、Practical Information：

1. This seminar is financially supported by the TYMRC. Accommodation and meals for participants will be covered by the Center. All other expenses (including round-trip transportation) shall be borne by the participants themselves.
2. The Center will arrange shuttle services to/from the following locations: Kunming High-Speed Railway Station, Kunming Changshui International Airport, and downtown Kunming. Participants are kindly requested to log in to the project management system (http://tianyuanpm.amss.ac.cn/) in a timely manner to register their travel information.

3. As the Center is located at a considerable distance from the nearest hospital, participants are advised to bring an adequate supply of essential personal medications.
4. Conference Contact:
   Dong Wang (The Chinese University of Hong Kong, Shenzhen), 18852840549

会议日程一（Schedule I）

11 月 22 日	
周日 Sunday	**报到（Registration）**
11 月 28 日	
周六 Saturday	**离会（Departure）**

11 月 23 日（周一 Monday）			
08:50-09:00	开幕式及合影 Opening Ceremony & Group Photo		
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
09:00-09:40	Manyu Xiao	大规模动态多保真缩减拓扑优化方法	Xiao-Ping Wang
09:40-10:20	Xuguang Yang	Thermodynamically Consistent Modeling and Simulation of Two-Phase Electrokinetic Flows	
10:20-10:40	讨论（Discussion over coffee）		
10:40-11:20	Xuping Wang	相场方程 Runge-Kutta 方法的能量耗散分析与平均耗散速率	Huangxin Chen
11:20-12:00	Jinpeng Zhang	An Efficient Scheme for a Phase-Field Model with Generalized Navier Boundary Conditions	
12:00-13:00	午餐（Lunch Break）		
13:00-14:30	Free Discussion		
14:30-15:50	Open discussion：Modelling of complex free interface problems		Xiao-Ping Wang
15:50-16:20	讨论（Discussion over coffee）		

16:20-17:40	Open discussion：Modelling of complex free interface problems	Xiao-Ping Wang
17:40-19:00	晚餐（Dinner Break）	

会议日程二（Schedule II）

11 月 24 日（周二 Tuesday）			
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
09:00-09:40	Qinghai Zhang	3D interface tracking with topological changes	Dong Wang
09:40-10:20	Xiangcheng Zheng	Complex boundary conditions of miscible flow and transport with application	
10:20-10:40	讨论（Discussion over coffee）		
10:40-11:20	Luchan Zhang	Continuum Models for Structures and Dynamics of Crystalline Interfaces	Xiangcheng Zheng
11:20-12:00	Jin Zhao	Evo-GTransNet Galerkin Methods for Parabolic and Phase-Field PDEs	
12:00-13:00	午餐（Lunch Break）		
13:00-14:30	Free Discussion		
14:30-15:10	Yuezheng Gong	A linearized supplementary variable method for the Cahn–Hilliard–Navier–Stokes system	Luchan Zhang
15:10-15:50	Fei Sun	变开度的不可压混合维裂缝模型的有限元方法	
15:50-16:20	讨论（Discussion over coffee）		
16:20-17:40	Open discussion：Numerical methods for complex free interface problems		Huangxin Chen

17:40-19:00	晚餐（Dinner Break）

会议日程三（Schedule III）

11 月 25 日（周三 Wednesday）			
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
09:00-09:40	Chuanju Xu	High order implicit-explicit linear multistep methods for gradient flows	Yuezheng Gong
09:40-10:20	Chaoyu Quan	A Domain Decomposition Method for the Poisson–Boltzmann Model	
10:20-10:40	讨论（Discussion over coffee）		
10:40-11:20	Paolo Piersanti	Geometrical Finite Element Methods for Obstacle Problems: Theory, Examples and Counterexamples	Chaoyu Quan
11:20-12:00	Qi Hong	Beyond Skew-Symmetry: A linear and fully decoupled energy-stable scheme for CHNS	
12:00-13:00	午餐（Lunch Break）		
13:00-17:30	Free Discussion		
17:30-19:00	晚餐（Dinner Break）		

会议日程四（Schedule IV）

11 月 26 日（周四 Thursday）			
时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair

09:00-09:40	Ziqing Xie	Finding Saddle Points of Non-convex Functionals via Minimization on Manifolds	Xianmin Xu
09:40-10:20	Tiezheng Qian	Variational Modelling and Numerical Simulations for Evaporating Thin Droplets and Coffee-Ring Effect	
10:20-10:40	讨论（Discussion over coffee）		
10:40-11:20	Na Lei	基于计算共形几何的结构化网格生成	Tiezheng Qian
11:20-12:00	Ruchi Guo	Optimization and preconditioning: TPDv algorithms for nonlinear PDEs	
12:00-13:00	午餐（Lunch Break）		
13:00-14:30	Free discussion		
14:30-15:10	Qiaolin He	An Immersed Interface Neural Network for Time-Dependent Interface Problems with Convergence Analysis	Ruchi Guo
15:10-15:50	Si Xiao	Modelling and Moving Mesh Methods for Thin Films with Moving Contact Lines	
15:50-16:20	讨论（Discussion over coffee）		
16:20-17:40	Open discussion：Theory for complex free interface problems		Xianmin Xu
17:40-19:00	晚餐（Dinner Break）		

会议日程五（Schedule V）

11 月 27 日（周五 Friday）

时间 Time	报告人 Speaker	题目 Title of talk	主持人 Chair
09:00-09:40	Piaopiao Dong	ICTM for Topology Optimization: Heat Transfer and Minimum Length-Scale Constraints	Si Xiao
09:40-10:20	Zixuan Cui	GPU Acceleration of AFEMAG for Demagnetizing Field Computation and LLG Simulation	
10:20-10:40	讨论（Discussion over coffee）		
10:40-11:20	Shimin Guo	Spectral schemes for Hall-Ambipolar MHD/Maxwell's equations	Xianmin Xu
11:20-12:00	Dongdong He	Mathematical modeling and numerical simulations for viscoelastic multi-phase flow problems.	
12:00-13:00	午餐（Lunch Break）		
13:00-17:30	Free discussion		
17:30-19:00	晚餐（Dinner Break）		

Participants：

1. Huangxin Chen — Xiamen University
2. Zixuan Cui — The Chinese University of Hong Kong, Shenzhen
3. Piaopiao Dong — The Chinese University of Hong Kong, Shenzhen
4. Yuezheng Gong — Nanjing University of Aeronautics and Astronautics
5. Ruchi Guo — Sichuan University
6. Shimin Guo — Xi'an Jiaotong University
7. Dongdong He — The Chinese University of Hong Kong, Shenzhen
8. Qiaolin He — Sichuan University
9. Qi Hong — Nanjing University of Aeronautics and Astronautics
10. Na Lei — Dalian University of Technology
11. Paolo Piersanti — The Chinese University of Hong Kong, Shenzhen
12. Tiezheng Qian — The Hong Kong University of Science and Technology
13. Chaoyu Quan — The Chinese University of Hong Kong, Shenzhen
14. Fei Sun — Xiamen University

15. Dong Wang — The Chinese University of Hong Kong, Shenzhen
16. Xiao-Ping Wang — The Chinese University of Hong Kong, Shenzhen
17. Xuping Wang — The Chinese University of Hong Kong, Shenzhen
18. Manyu Xiao — Northwestern Polytechnical University
19. Si Xiao — Fuzhou University
20. Ziqing Xie — Hunan Normal University
21. Chuanju Xu — Xiamen University
22. Xianmin Xu — Academy of Mathematics and Systems Science, Chinese Academy of Sciences
23. Xuguang Yang — Hunan First Normal University
24. Jinpeng Zhang — University of Macau
25. Luchan Zhang — Shenzhen University
26. Qinghai Zhang — Zhejiang University
27. Jin Zhao — Capital Normal University
28. Xiangcheng Zheng — Shandong University