



天元數學國際交流中心

Tianyuan Mathematics Research Center

2026 中法偏微分方程及其应用研讨会

2026 China-France Joint Workshop on Partial Differential
Equations and Their Applications

TY-2026-C-090

会议手册

Conference Program

2026 年 5 月 31 日—6 月 6 日

May 31-June 6, 2026

中国·昆明

Kunming, China

Registration: May 31, 2026 (Sunday)

June 1, 2026 (Monday)

8:50-9:00	Opening Ceremony	
Time	Speaker	Title
9:00-9:50	Ping Zhang	3D classical Navier-Stokes vs anisotropic Navier-Stokes equations
9:50-10:10	Tea/Coffee Break	
10:10-11:00	Dejun Luo	Anomalous regularity and well-posedness of 2D inviscid Boussinesq system with Kraichnan transport noise
11:00-11:50	Mathieu Laurière	Dual approaches to stochastic control via SPDEs and the pathwise Hopf formula
11:50-14:30	Lunch/Break	
14:30-15:30	Yvain Bruned	Arborification for dispersive PDEs (I)
15:30-15:50	Tea/Coffee Break	
15:50-16:50	Början Geshkovski	On the mathematics behind ChatGPT (I)
16:50-17:40	Ning Liu	Long-time behavior of two-dimensional Navier-Stokes equations in the presence Couette flow on the half plane
17:40-19:00	Dinner	

June 2, 2026 (Tuesday)		
Time	Speaker	Title
9:00-9:50	Fabrice Bethuel	Two-dimensional singular harmonic maps into one-dimensional singular harmonic maps
9:50-10:10	Tea/Coffee Break	
10:10-11:00	Wendong Wang	Recent results on critical mass and blow-up suppression for some Patlak-Keller-Segel-Navier-Stokes systems
11:00-12:00	Yvain Bruned	Arborification for dispersive PDEs (II)
12:20-15:00	Lunch/Break	
15:00-16:00	Början Geshkovski	On the mathematics behind ChatGPT (II)
16:00-16:20	Tea/Coffee Break	
16:20-17:10	Te Li	Nonlinear asymptotic stability and optimal decay rate around the three-dimensional Oseen vortex filament
17:10-17:50	Yibin Zhang	Long time evolution of a pair of 2D viscous point vortices
17:50-19:00	Dinner	

June 3, 2026 (Wednesday)		
8:50-9:00	Group Photo	
Time	Speaker	Title
9:00-9:50	Shi Jin	Quantum computations of PDEs and the UnitaryLab software
9:50-10:10	Tea/Coffee Break	
10:10-11:00	Buyang Li	Continuous formulation of numerical schemes for nonlinear dispersive equations
11:00-12:00	Yvain Bruned	Arborification for dispersive PDEs (III)
12:00-15:00	Lunch/Break	
15:00-17:30	Free Discussions	
17:30-19:00	Dinner	

June 4, 2026 (Thursday)		
Time	Speaker	Title
9:00-9:50	Xiaoying Dai	Orthogonality preserving methods for electronic structure calculations
9:50-10:10	Tea/Coffee Break	
10:10-11:00	Shengquan Xiang	Exponential mixing for the randomly forced NLS equation
11:00-11:50	Nicolas Moench	A general paracontrolled ansatz for singular SPDEs
11:50-14:30	Lunch/Break	
14:30-15:20	Huajie Chen	Momentum space approach for incommensurate structures
15:20-15:40	Tea/Coffee Break	
15:40-16:40	Början Geshkovski	On the mathematics behind ChatGPT (III)
16:40-17:40	Yvain Bruned	Arborification for dispersive PDEs (IV)
17:40-19:00	Dinner	

June 5, 2026 (Friday)		
Time	Speaker	Title
9:00-9:50	Sami Mustapha	Discrete harmonic functions in Lipschitz domains: existence, uniqueness and boundary behavior
9:50-10:10	Tea/Coffee Break	
10:10-11:00	Xianmin Xu	Modeling and numerical methods for two-phase flow with moving contact lines
11:00-11:50	Haitian Yue	Probabilistic scaling propagation of randomness under nonlinear dispersive flow
11:50-14:30	Lunch/Break	
14:30-15:30	Början Geshkovski	On the mathematics behind ChatGPT (IV)
15:30-15:50	Tea/Coffee Break	
15:50-16:40	Xueting Jin	Local well-posedness of D-dimensional incompressible MHD equations with only magnetic diffusion
16:40-17:20	Dongheng Liu	Existence of heteroclinic solution in Allen-Cahn system
17:20-19:00	Dinner	

Departure: June 6, 2026 (Saturday)

Title and Abstract

Two-dimensional singular harmonic maps into one-dimensional singular harmonic maps

Fabrice Bethuel

(Sorbonne University, France)

The presentation is devoted to some recent results concerning singular harmonic maps into the wedge of two circles $S^1 \times S^1$. I will emphasize various aspects of the problem, in particular its renormalized energy and show that it is related to prescribing periods of meromorphic differential on specific compact Riemann surfaces. The results are mostly from the recent thesis of Mehdi Trense and I will also focus on a number of open problems.

Arborification for dispersive PDEs

Yvain Bruned

(University of Lorraine, France)

In this mini-course, we will introduce the decorated trees needed for encoding the oscillatory integrals that appear when one iterates Duhamel's formula for dispersive PDEs. The solutions of these equations can be expanded using a B-series formalism. Then, we introduce the main combinatorial map called arborification that allows us to send these decorated trees to words. With this change of perspective, one gets a new derivation of the Poincaré-Dulac normal form, the cancellations coming from Wave turbulence and the proof of the invariance of the Gibbs measure for the three-dimensional cubic wave equation, and the resonance-based schemes.

Momentum space approach for incommensurate structures

Huajie Chen

(Beijing Normal University, China)

Incommensurate structures come from stacking the single layers of low-dimensional materials on top of one another with misalignment such as a twist in orientation. While these structures are of significant physical interest, they pose many theoretical challenges due to the loss of periodicity. In this talk, we study the physical observables of continuum Hamiltonian operators for incommensurate systems. We characterize the density of states and local density of states in real and reciprocal spaces, and develop a novel momentum space approach to approximate them. In particular, we (i) justify the thermodynamic limit of the density of states and local density of states via the operator kernel characterization; and (ii) propose efficient numerical schemes based on efficient discretization in momentum space. We further generalize this framework to (i) nonlinear Hamiltonian and (ii) incommensurate systems with atomic relaxations.

Orthogonality preserving methods for electronic structure calculations

Xiaoying Dai

(AMSS, CAS, China)

To obtain convergent numerical approximations without orthogonalization operations is of great importance in electronic structure calculations. In this talk, we will introduce an extended gradient flow based Kohn-Sham DFT model, for which we prove that the flow is orthogonality preserving and that the solution evolves to the ground state. With the help of the extended gradient flow based Kohn-Sham DFT model, we propose some iteration schemes for the discretized Kohn-Sham model, which are proved to preserve the orthogonality of the Kohn-Sham orbitals automatically. With our schemes, the iterative approximations are guaranteed to converge to the Kohn-Sham orbitals without any orthogonalization operations when the initial orbitals are orthogonal.

On the mathematics behind ChatGPT

Början Geshkovski

(Sorbonne University, France)

In this lecture, we will describe how Transformers, the neural network architecture behind all large language models, are in fact a class of interacting particle systems in disguise. Tokens (word embeddings) play the role of particles, and layers that of time. Mean-field limits are also natural in this context due to the ever-increasing context length of language models, giving rise to a non-local PDE. We will discuss how this perspective allows us to rigorously prove several empirically observed phenomena, and impact design choices in practice.

Quantum computations of PDEs and the UnitaryLab software

Shi Jin

(Shanghai Jiao Tong University, China)

Quantum computers are designed based on quantum mechanics principle, they are most suitable to solve the Schrodinger equation, and linear PDEs (and ODEs) evolved by unitary operators. Nonlinearity and Nonunitarity are the main challenges for quantum simulations of PDEs. For linear PDEs (and ODEs) Schrodingerization provides a general method to unitarize them for quantum simulation. For nonlinear problems we first introduce our quantum algorithms for (nonlinear) Hamilton-Jacobi equations, for both multi-valued solutions and viscosity solutions that are needed beyond the formation of caustics. We also introduce quantum algorithms for Young measures associated with nonlinear PDEs, which are effective tools to compute weak solutions to nonlinear PDEs that have singular solutions such as shocks, caustics, physical instabilities or (random) uncertainties. We also introduce “UnitaryLab”, which is an AI-powered research software package of quantum algorithms for scientific computing.

Local well-posedness of D-dimensional incompressible MHD equations with only magnetic diffusion

Xueting Jin

(AMSS, CAS, China)

Dual approaches to stochastic control via SPDEs and the pathwise Hopf formula

Mathieu Laurière
(NYU Shanghai)

We develop dual approaches for continuous-time stochastic control problems, enabling the computation of robust dual bounds in high-dimensional state and control spaces. Building on the dual formulation proposed in [L. C. G. Rogers, *SIAM Journal on Control and Optimization*, 46 (2007), pp. 1116–1132], we first formulate the inner optimization problem as a stochastic partial differential equation (SPDE); the expectation of its solution yields the dual bound. Curse-of-dimensionality-free methods are proposed based on the Pontryagin maximum principle and the generalized Hopf formula. In the process, we prove the generalized Hopf formula, first introduced as a conjecture in [Y. T. Chow, J. Darbon, S. Osher, and W. Yin, *Journal of Computational Physics* 387 (2019), pp. 376–409], under mild conditions. Numerical experiments demonstrate that our dual approaches effectively complement primal methods, including the deep BSDE method for solving high-dimensional PDEs and the deep actor-critic method in reinforcement learning. Joint work with Jiefei Yang (NYU Shanghai).

Continuous formulation of numerical schemes for nonlinear dispersive equations

Buyang Li
(The Hong Kong Polytechnic University, China)

This article is concerned with the construction and analysis of new time and space discretizations for the KdV equation and the nonlinear Schrödinger (NLS) equation on a torus for low-regularity solutions below H^1 . A new framework of stability analysis, based on Continuous formulation of numerical schemes, is introduced to establish stability estimates of numerical schemes under low-regularity conditions without requiring CFL conditions as in the pre-existing approaches. In addition, new harmonic analysis tools, including averaging approximations to the exponential phase functions, and high-frequency recovery techniques are established for the construction and analysis of time discretizations with higher convergence orders under low-regularity conditions. For the KdV equation, the proposed method is proved to be convergent with order γ in L^2 under the regularity condition $u \in C([0, T]; H^\gamma)$ for $\gamma \in (0, 1]$. For the NLS equation, the proposed method is proved to be convergent with order 1.5γ in L^2 under the regularity condition $u \in C([0, T]; H^\gamma)$ for $\gamma \in (0, \frac{1}{2}]$.

Nonlinear asymptotic stability and optimal decay rate around the three-dimensional Oseen vortex filament

Te Li

(AMSS, CAS, China)

In the high-Reynolds-number regime, this work investigates the long-time dynamics of the three-dimensional incompressible Navier–Stokes equations near the Oseen vortex filament. The flow exhibits a strong interplay between vortex stretching, shearing, and mixing, which generates ever-smaller spatial scales and thereby significantly amplifies viscous effects. By adopting an anisotropic self-similar coordinate system adapted to the filament geometry, we establish the nonlinear asymptotic stability of the Oseen vortex filament. All non-axisymmetric perturbations are shown to decay at the optimal rate $t^{-\kappa|\alpha|^{1/2}}$. At the linear level, this decay mechanism corresponds to a sharp spectral lower bound $\Sigma(\alpha) \sim |\alpha|^{1/2}$ for the nonlocal Oseen operator $L_{\perp} - \alpha\Lambda_{\perp}$, and we identify an explicit spectral point attaining this optimal bound. Combined with the spectral estimates obtained in [25], our analysis fully resolves the conjecture proposed in [12] concerning the asymptotic scaling laws for the spectral and pseudospectral bounds $\Sigma(\alpha)$ and $\Psi(\alpha)$. These results provide a rigorous mathematical explanation for the shear–mixing mechanism in the vicinity of the 3D Oseen vortex filament.

Existence of heteroclinic solution in Allen-Cahn system

Dongheng Liu

(Sorbonne University, France)

This report mainly focuses on heteroclinic solutions in Allen-Cahn system. Firstly, we discuss about scalar case. We introduce the variational method, 1D heteroclinic solutions, Clearing-Out lemma, exponential decay, and discrepancy function. Extending the problem in higher dimensions, we show that the interface converges to a minimal surface when ε goes to 0. The last part is the Vectorial case, where many properties are no longer holding. We use the mountain-pass theorem to construct a 1D heteroclinic solution, which is not an energy minimizer. By the same way, we also investigate a periodic solution on a cylinder, which has no trivial period.

Long-time behavior of two-dimensional Navier-Stokes equations in the presence Couette flow on the half plane

Ning Liu

(NYU Abu Dhabi)

In this talk, we study the long-time behavior of solutions to the two-dimensional Navier-Stokes equations in the presence of Couette flow on the half plane with Navier-slip boundary conditions. We prove that the vorticity will approach the vertical momentum multiplying the kernel of a Fokker-Planck type operator $\mathcal{L} = \partial_Y^2 + \frac{3}{2}X\partial_X + \frac{1}{2}Y\partial_Y + \frac{5}{2} - Y\partial_X$. In the proof, we introduce a new idea of studying the spectrum of such type operators with boundary. This is a joint work with Nader Masmoudi and Weiren Zhao.

Anomalous regularity and well-posedness of 2D inviscid Boussinesq system with Kraichnan transport noise

Dejun Luo

(AMSS, CAS, China)

Inspired by recent progress on the theory of regularization by noise for 2D fluid equations, we consider the stochastic 2D inviscid Boussinesq system driven by Kraichnan transport noise with parameter $\alpha \in (0, 1/2)$. It is shown that the noise provides anomalous regularity for weak solutions with L^p initial data, enabling us to prove pathwise uniqueness of solutions. This demonstrates that suitable noise improves the solution theory of the 2D inviscid Boussinesq system. The talk is based on a joint work with Dr. Shuaijie Jiao.

A general paracontrolled ansatz for singular SPDEs

Nicolas Moench

(University of Lorraine, France)

Singular SPDEs are stochastic partial differential equations with ill-defined nonlinearities caused by a lack of regularity, consequently a renormalisation procedure is required. In this talk, we will present the paracontrolled approach, first introduced by Gubinelli, Imkeller, and Perkowski for the study of such equations. We will discuss the main ingredients of the paracontrolled strategy used to define these ill-defined products, and explain how these tools can be generalised in order to construct a general paracontrolled ansatz for a broad class of subcritical SPDEs. This is based on a joint work with Yvain Bruned.

Discrete harmonic functions in Lipschitz domains: existence, uniqueness and boundary behavior

Sami Mustapha

(Sorbonne University, France)

This talk is devoted to the study of positive discrete harmonic functions associated with a broad class of spatially inhomogeneous random walks in Lipschitz domains. Motivated by classical questions at the interface of probability theory, discrete potential theory, and harmonic analysis, we investigate boundary value problems for non-homogeneous Markov processes in geometrically nontrivial settings. We present recent results establishing the existence and uniqueness of positive harmonic functions satisfying Dirichlet boundary conditions in Lipschitz domains for a large class of finite-range, uniformly elliptic random walks under suitable drift integrability assumptions. These results extend several earlier works that were restricted to simpler geometries, such as half-spaces or orthants, or to centered random walks, and provide a more flexible framework for understanding the boundary behavior of discrete harmonic functions in irregular domains. A central aspect of the proof relies on comparison arguments inspired by boundary harmonic analysis. In particular, we develop discrete counterparts of classical tools such as Carleson-type estimates and boundary Harnack principles, which allow us to control the behavior of harmonic functions near the boundary despite the spatial inhomogeneity of the walk.

Recent results on critical mass and blow-up suppression for some Patlak-Keller-Segel-Navier-Stokes systems

Wendong Wang

(Dalian University of Technology, China)

It is well-known that the solution of the Patlak-Keller-Segel system in 2D has a critical mass of 8π and in 3D may blow up in finite time regardless of any initial cell mass. Here we are interested in the critical mass threshold and suppression of blow-up for some Patlak-Keller-Segel-Navier-Stokes system via the Couette flow or not.

Exponential mixing for the randomly forced NLS equation

Shengquan Xiang

(Peking University, China)

We explore exponential mixing of the invariant measure for randomly forced nonlinear Schrödinger equation, with damping and random noise localized in space. This study emphasizes the crucial role of dispersive nonlinear smoothing and control properties. This talk is based on the recent joint work with Yuxuan Chen, Zhifei Zhang and Jia-Cheng Zhao.

Modeling and numerical methods for two-phase flow with moving contact lines

Xianmin Xu

(AMSS, CAS, China)

Modeling and simulating two-phase flows with moving contact lines pose significant challenges in fluid dynamics due to the problem's multi-scale and multi-physics nature. A continuum model must consider the nanoscale slip near a contact line. While there are numerous microscopic models available, applying them to macroscopic two-phase flow problems is extremely difficult, especially when dealing with rough or chemically inhomogeneous solid boundaries. In this presentation, I will discuss recent progress in modeling and simulations for complex moving contact line problems. Specifically, I will demonstrate the effectiveness of utilizing the Onsager variational principle as a powerful approximation tool. We derive coarse-grained boundary conditions for moving contact line problems, both with and without contact angle hysteresis. These boundary conditions apply to the two-phase Navier-Stokes equations or a thin film equation; they thus serve as the foundation for developing efficient numerical methods to solve macroscopic two-phase flow problems. Finally, I will also show some recent analysis on a numerical scheme for a phase-field model for moving contact lines.

Probabilistic scaling & propagation of randomness under nonlinear dispersive flow

Haitian Yue

(Shanghai University of Science and Technology, China)

In this talk we will first survey recent developments on the study of random data problems for nonlinear (dispersive) PDEs. Then we will explain how the "correct" scaling heuristics for the critical regularity of wellposedness works in the probabilistic context and how it opened the door to unveil the random structures of nonlinear waves as they propagate. This is joint work with Yu Deng (UChicago) and Andrea Nahmod (UMass Amherst).

3D classical Navier-Stokes vs anisotropic Navier-Stokes equations

Ping Zhang

(AMSS, CAS, China)

Long time evolution of a pair of 2D viscous point vortices

Yibin Zhang

(AMSS, CAS, China)

This paper studies the long-time evolution of two point vortices under the 2D Navier–Stokes equations. Starting from initial data given by a pair of Dirac measures, we derive an asymptotic expansion for the vorticity over time scales significantly longer than the advection time, yet shorter than the diffusion time, via constructing suitable approximate solutions and employing Arnold's method.

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