International Workshop on PDE—constrained Optimization: Theory, Numerics and Applications

14—20 June, 2026

Tianyuan Mathematics Research Center, Kunming, China

Organizing Committee:

Prof. Eduardo Casas, University of Cantabria, Spain

Prof. Martin J. Gander, University of Geneva, Switzerland

Prof. Wei Gong, Chinese Academy of Sciences, China

Prof. Jan Sokołowski, Polish Academy of Sciences, Poland & Université de Lorraine, France

Prof. Shulin Wu, Northeast Normal University, China

Prof. Shengfeng Zhu, East China Normal University, China

※ Meeting Reminders ※

1．Safety Notice

2．Meal Arrangements

3．Shuttle Bus Arrangements

4．Conference Logistics Contact

Program

June 14-20, 2026   Tianyuan Mathematics Research Center, Kunming, Yunnan Province

Time		Title	Speaker	Chair
6/14(Sun)	**All Day**	Registration and Check In		
6/15(Mon)	09:00-09:40	Global convergence in function space and numerical analysis of steepest descent in PDE constrained shape optimization	Michael Hinze	Charles Dapogny
	09:40-10:20	Tea Break		
	10:20-11:00	Variational analysis for optimal control problems for history-dependent elliptic inclusions	Stanisław Migorski	Shengfeng Zhu
	11:00-11:40	Shape and topology optimization of regions supporting boundary conditions	Charles Dapogny	
	11:40-15:00	Lunch Break		
	15:00-15:40	A finite element method for phase-field dependent topology optimization in Stokes flow	Yifeng Xu	Wei Gong
	15:40-16:20	Tea Break		
	16:20-17:00	Topology optimization on surfaces by a surface type phase field method	Jiajie Li	Jan Sokołowski
	17:00-17:40	On Lagrange multipliers of constrained optimization in Hilbert spaces	Zhiyu Tan	
6/16(Tue)	09:00-09:40	Gradient flow dynamical system for shape optimization	Jan Sokołowski	Gengsheng Wang
	09:40-10:20	Tea Break		
	10:20-11:00	Geometric characteristics of observable regions/sets	Gengsheng Wang	Eduardo Casas

	11:00-11:40	Controlled geometric flows of maps	Shengquan Xiang	
	11:40-14:30	Lunch Break		
	14:30-17:30	Free discussion		
6/17(Wed)	09:00-09:40	Solving PDE-constrained optimization problems in parallel	Martin J. Gander	Stanisław Migorski
	09:40-10:20	Tea Break		
	10:20-11:00	Optimized Schwarz method in Time for the control of wave-like equations	Laurence Halpern	Martin J. Gander
	11:00-11:40	A diagonalization-based preconditioner for parabolic optimal control problems	Sean Y S Hon	
	11:40-14:30	Lunch Break		
	14:30-17:30	Free discussion		
6/18(Thu)	09:00-09:40	Second order analysis for optimal control problems: improving results expected from abstract theory	Eduardo Casas	Michael Hinze
	09:40-10:20	Tea Break		
	10:20-11:00	A finite element method for distributed control of indefinite time-harmonic Maxwell's equations	Gang Chen	Yanping Chen
	11:00-11:40	Time domain decomposition for PDE-constrained optimization	Liudi Lu	
	11:40-14:30	Lunch Break		
	14:30-17:30	Free discussion		

6/19(Fri)	09:00-09:40	Hierarchical domain decomposition methods with coarse correction	Hui Zhang	Laurence Halpern
	09:40-10:20	Tea Break		
	10:20-11:00	An investigation of multigrid methods for the Helmholtz equation with Dirichlet/Robin boundary condition	Yafei Sun	Shulin Wu
	11:00-11:40	From optimization to reduction: efficient coarse propagators in the parareal method	Qingle Lin	
	11:40-14:30	Lunch Break		
	14:30-17:30	Free discussion		
6/20(Sat)	09:00-12:00	Departure		

Titles and Abstracts

Second order analysis for optimal control problems：improving results expected from abstract theory

Eduardo Casas
University of Cantabria, Spain

Abstract: An abstract optimization problem of minimizing a functional on a convex subset of a Banach space is considered. I discuss natural assumptions on the functional that permit to establish sufficient second-order optimality conditions with minimal gap with respect to the associated necessary ones. Though the two-norm discrepancy is taken into account, the obtained results exhibit the same formulation than the classical ones known from finite-dimensional optimization. I show that these assumptions are fulfilled in particular by important optimal control problems for partial differential equations. We prove that, in contrast to a widespread common belief, the standard second-order conditions formulated for these control problems imply strict local optimality of the controls not only in the sense of L^∞, but also in that of L^2.

A finite element method for distributed control of indefinite time—harmonic Maxwell's equations

Gang Chen
Sichuan University, China

Abstract: We study the problem of approximating the distributed optimal control problem governed by the indefinite time-harmonic Maxwell's equations with the Nédélec's finite elements. First, we derive the wavenumber explicit regularity result. Second, we present the error analysis, for which the state and the control can reach the optimal order of approximation, with constant independent of the wavenumber. Then, to solve the indefinite system, we give a method based on the classical AMS preconditioner and prove that the converges of this method are dependent on the wave number but independent of the mesh size. Numerical experiments confirm our theoretical results.

Shape and topology optimization of regions supporting boundary conditions

Charles Dapogny

Sorbonne Université, France

Abstract: Shape optimization generally aims to optimize the design of a 2d or 3d domain with respect to an objective function of the domain. In applications, this function usually depends on the shape via to solution to a "physical"' partial differential equation, accompanied with boundary conditions accounting for the effects of the exterior medium. For instance, a mechanical structure is characterized by its displacement, solution to the linear elasticity system, equipped with boundary conditions of homogeneous Dirichlet (modeling fixation regions), homogeneous or inhomogeneous Neumann (accounting for the absence or presence of traction loads) types.

Most often, only one part of the boundary of the shape is optimized -- typically, the traction-free boundary in structural mechanics. The aim of this presentation is, on the contrary, to consider the optimization of these regions bearing the boundary conditions of the physical problem at play. This question is investigated from two complementary viewpoints.

- We investigate the shape derivative of a shape functional in the sense of Hadamard, when the involved deformations do not vanish where the boundary conditions change types: this allows to optimize how the regions bearing these conditions may "slide" along the boundary of the shape.
- We consider the sensitivity of the solution to a physical problem (and that of a related quantity of interest) when a small region bearing a certain type of boundary conditions (typically, of homogeneous Dirichlet type) is nucleated within a region bearing other conditions (e.g. of Neumann type). This paves the way to a notion of "topological derivative" describing change of boundary conditions.

Several numerical examples are presented in two and three space dimensions in the contexts of conductivity, acoustics and elasticity. This presentation is based on a series of joint works with Eric Bonnetier, Carlos Brito-Pacheco, Rafael Estevez, Nicolas Lebbe, Edouard Oudet and Michael Vogelius.

Solving PDE—constrained optimization problems in parallel

Martin J. Gander

University of Geneva, Switzerland

Abstract: In PDE-constrained optimization, a classical question is whether one should

- first discretize and then optimize, or
- first optimize and then discretize.

In this talk, I will introduce a related question arising in the parallel solution of PDE-constrained optimization problems using domain decomposition methods:

- should one first decompose and then optimize, or
- first optimize and then decompose?

The optimize-then-decompose approach has received considerable attention in the literature, particularly for the parallel solution of steady PDE-constrained optimization problems. I will show that, for time-dependent problems, this strategy naturally leads to new Parallel-in-Time (PinT) methods when the time interval is decomposed into temporal subdomains. I will illustrate this connection with the new Schwarz-in-time methods and ParaOpt.

I will then discuss the alternative decompose-then-optimize approach. Applying an augmented Lagrangian technique to such decomposed formulations leads to a new class of domain decomposition algorithms for PDE-constrained optimization problems, which, at least at present, does not appear to fit into the framework of classical domain decomposition methods.

Optimized Schwarz method in Time for the control of wave–like equations

Laurence Halpern

Université Sorbonne Paris-Nord, France

Abstract: We investigate optimized Schwarz domain decomposition methods in time for the control of wave and transport equation. For the wave equation, we introduce a time domain decomposition strategy on the Euler system. Using a matrix trigonometric analysis, we analyse an alternate inherited (in time) algorithm and a relaxed iteration.

For the transport equation, we study the optimization of Robin coefficients at the PDE level and for the numerical scheme. We study the properties of the algorithm, both as an iterative process or a preconditioned for the GMRES process.

Global convergence in function space and numerical analysis of steepest descent in PDE constrained shape optimization

Michael Hinze
University of Koblenz-Landau, Germany

Abstract: We present a general shape optimization framework based on the method of mappings in the Lipschitz topology. We propose and numerically analyse steepest descent (and Newton-like) minimization algorithms for the numerical solution of the respective shape optimization problems. In particular, we prove global convergence of steepest descent with Armijo stepsize rule in function space. To illustrate our approach we present a selection of PDE constrained shape optimization problems and compare our findings to results from so far classical Hilbert space methods and recent p-approximations. If time permits, we also present a hybrid approach which combines a phase-field approach with our sharp framework. (joint with Klaus Deckelnick and Philip Herbert).

A diagonalization—based preconditioner for parabolic optimal control problems

Sean Y S Hon

Hong Kong Baptist University, China

Abstract: In this work, we propose a novel diagonalization-based preconditioner for the all-at-once linear system arising from the optimal control problem of parabolic equations. The proposed preconditioner is constructed based on an ?? -circulant modification to the rotated block diagonal (RBD) preconditioning technique and can be efficiently diagonalized by fast Fourier transforms. Compared with those Schur complement based preconditioning techniques in the literature, the advantage of the proposed ?? -circulant modified RBD preconditioning is that it does not involve the multiplication of forward and backward evolutionary processes. The generalized minimal residual (GMRES) method is deployed on the preconditioned system, and we prove that the convergence rate of the preconditioned GMRES solver is independent of the matrix size and the regularization parameter when choosing ?? =O?(???) with ?? being the temporal step-size. Numerical results are provided to demonstrate the effectiveness of our proposed solvers.

Topology optimization on surfaces by a surface type phase field method

Jiajie Li

The Hong Kong Polytechnic University, China

Abstract: Topology optimization on surfaces governed by a surface diffusion equation is studied in both mathematical analysis and numerical implementation. We aim to investigate the optimal distribution of two materials on the surface to minimize certain objective. Within the framework of the surface phase field model, we prove the existence of a minimizer for the PDE-constrained optimization problem. We show the differentiability of the solution operator w.r.t. the phase field. A stabilized scheme for the gradient flow of variational inequality type is proposed, and the corresponding energy stability is analyzed. Moreover, the proposed scheme is shown to preserve the bound of the phase-field and converge to the first-order optimality condition. Finally, numerical examples effectively validate the proposed optimization algorithm.

From optimization to reduction：efficient coarse propagators in the parareal method

Qingle Lin
The Hong Kong Polytechnic University, China

Abstract: The Parareal method is a powerful parallel-in-time framework for accelerating the numerical solution of evolution equations, but its efficiency critically depends on the design of the coarse propagator. In this talk, we present a unified perspective on efficient coarse propagation, moving from optimization-based coarse solvers to reduced-order and predictive coarse models. We first present systematic strategies for constructing optimized coarse propagators that improve convergence, including one-step and two-step formulations designed through quantitative error estimates. We then introduce a reduced coarse solver and interpret its effect as a perturbation of the standard Parareal iteration. Under a structural assumption on the discrepancy between the reduced and standard coarse propagators, the reduced parareal scheme can be reformulated as a classical Parareal iteration with an additional data-dependent perturbation term. This viewpoint leads to a predictive error model for the mean-square error quantity, which clarifies how reduced coarse solvers affect convergence across Parareal iterations. Finally, we illustrate the theory with numerical examples, demonstrating how suitable reduction strategies can preserve accuracy while substantially lowering coarse-solver cost.

Time domain decomposition for PDE—constrained optimization

Liudi Lu

Lund University, Sweden

Abstract: Despite decades of advances in parallel computing, the time dimension has remained largely unexploited for parallelization. At first glance, parallelization in time seems paradoxical: the solution of a time-dependent partial differential equation (PDE) at a future instant cannot be computed without knowledge of the past. This sequential behavior appears to preclude any temporal decomposition. However, in the setting of PDE-constrained optimization, the special structure of the first-order optimality system "weakens" this causality principle, and thus opens the door to a new and largely unexplored paradigm for time-parallel computation. In this talk, we will explore some non-overlapping domain decomposition algorithms to solve this forward-backward optimality system. We will introduce the idea of time domain decomposition and compare it with the space decomposition, the so-called waveform relaxation methods. Based on the forward-backward structure of the optimality system, we will then discuss some properties of classical domain decomposition methods in the time decomposition framework. Some tests will be shown to reveal numerical properties of these methods.

Variational analysis fo optimal control problems for history–dependent elliptic inclusions

Stanislaw Migorski
Jagiellonian University, Poland

Abstract: In this paper we examine a Lagrange optimal control problem for a new class of elliptic time-dependent operator inclusions involving history-dependent operators. First, results on existence and variational sensitivity of optimal control problem are proved. Next, the lower and upper Kuratowski semicontinuity of the admissible sets, sets of optimal solutions, and the continuity of the value function are shown with respect to a parameter which appears in the inclusion and the integrand of the cost functional. Finally, we illustrate the applicability of the results to a quasi-static viscoelastic frictional contact problem in mechanics.

Gradient flow dynamical system for shape optimization

Jan Sokołowski

Polish Academy of Sciences, Poland

Université de Lorraine，France

Abstract: This lecture presents the gradient flow dynamical system (GFDS) as a deterministic framework for PDE-constrained shape optimization. The design variable is a subdomain $\omega \Subset \Omega$ with boundary $\Gamma = \partial\omega$. A shape objective $\Phi(\omega)$ is minimized by moving Γ in an artificial descent time according to the Hadamard shape derivative. Thus the method does not define an “optimal shape” by an external label or by a black-box prediction; the accepted shape is the terminal shape selected and verified by the fixed GFDS protocol.

The continuous formulation uses admissible smooth shapes and represents the shape derivative through a boundary density. The physical part of the objective may be a Kohn–Vogelius mismatch for inverse interface identification or a reduced heat-control value for actuator-location problems. Geometric regularization is introduced through the planar Willmore, or elastica, functional

$$W(\partial\omega) = \frac{1}{2}\int_{\partial\omega} \kappa^2 \, ds,$$

combined with either a soft area penalty or a hard area constraint. For the penalized problem the normal velocity is the negative total shape density, while for the hard-area problem the density is projected by subtracting its boundary average. In both cases the GFDS gives a descent identity: the objective is non-increasing along smooth admissible trajectories, and the derivative vanishes only at stationary configurations of the selected problem.

After finite-dimensional parametrization, $\omega = \omega(q)$ with $q \in Q_{\mathrm{ad}} \subset \mathrm{R}^d$, the GFDS takes the form

$$M(q(\tau))\dot{q}(\tau) = -\nabla\Phi(q(\tau)),$$

where $M(q)$ is a symmetric positive definite metric matrix. This defines a finite-time map from the initial parameter q^0 to $q(A;\, q^0)$ and, when the trajectory converges, a terminal selection map $G_\infty(q^0) = q^*$. If several stationary shapes exist, this terminal map is basin-dependent and need not be continuous across basin boundaries.

Two explicit shape families illustrate the construction. For disks, $q = (c_1, c_2, r)$ and the Willmore energy is exactly π/r; therefore the Willmore term affects the disk GFDS only when the radius is allowed to vary. For ellipses, the parameters include the center, semi-axes, and rotation angle. The ellipse model supplies explicit normal velocities, area derivatives, curvature, and Willmore derivatives, and is used with a Willmore-regularized Kohn–Vogelius functional comparing Dirichlet and Neumann heat reconstructions.

The lecture also explains how neural differential equations can be used only as finite-dimensional surrogates of the deterministic GFDS map. They may learn the terminal map, a finite-time GFDS flow, or the GFDS vector field from trajectories generated by the verified solver. The approximation claim is restricted to compact parameter sets on which the GFDS-defined target map is continuous. The final mathematical solution remains the GFDS solution, or a GFDS refinement of the neural prediction, after recomputation of the PDE residuals, the objective, constraints, descent, and stationarity conditions.

An investigation of multigrid methods for the Helmholtz equation with Dirichlet/Robin boundary condition

Yafei Sun
Jilin University, China

Abstract: Domain decomposition and multigrid methods are widely regarded as efficient iterative techniques for solving differential equations. A detailed numerical study shows that, when solving one-dimensional Helmholtz problems with different physical outer boundary conditions (cavity and free space problems), both methods exhibit poor convergence for cavity problems with Dirichlet outer boundary conditions. However, for free-space problems with impedance outer boundary conditions, optimized Schwarz methods can perform very well, whereas the two-grid (and consequently multigrid) method struggles, as it does for the cavity problem. We provide a preliminary theoretical explanation for the failure of the multigrid algorithm and experimentally verify some of the theoretical findings. This is a continuation of the talk at the DD29 conference and was carried out in collaboration with Martin. J. Gander.

On Lagrange multipliers of constrained optimization in Hilbert spaces

Zhiyu Tan
Xiamen University, China

Abstract: In this paper we introduce the essential Lagrange multiplier and establish a solid mathematical foundation of constrained optimization in Hilbert spaces, which includes the mathematical foundation of quadratic-programming based methods such as the SQP method, the necessary and sufficient conditions for the existence and uniqueness of Lagrange multipliers, the essential difference of the theory of Lagrange multipliers in finite and infinite-dimensional spaces and an essential characterization of the convergence of the classical augmented Lagrangian method. They are achieved by a newly developed decomposition framework for Lagrange multipliers of the Karush-Kuhn-Tucker system of constrained optimization problems in Hilbert spaces.

Geometric characteristics of observable regions/sets

Gengsheng Wang

Hetao Institute of Mathematics and Interdisciplinary Sciences, China

Abstract: Observability is one of the core research areas in control theory. Different forms of observability inequalities not only correspond to distinct control phenomena but also possess their own mathematical significance. For evolutionary partial differential equations (PDEs), investigating the geometric characteristics of their observable sets/regions is a key component in studying the corresponding observability inequalities. However, research in this field remains far from comprehensive. In this talk, we first present several distinct observability inequalities within the framework of abstract evolution equations, together with their corresponding control problems. We then introduce the concepts of observable sets and regions for evolutionary PDEs, followed by a review of existing results and main research methods regarding the geometric characteristics of these sets/regions. Finally, we outline a number of open problems related to the geometric characteristics of observable (including weakly observable) sets/regions.

Controlled geometric flows of maps

Shengquan Xiang
Peking University, China

Abstract: In this talk, we discuss controlled geometric flows of maps, motivated by the heat flow and wave maps, in which control is incorporated into geometric evolution equations. Unlike classical control problems in flat PDE settings, the geometry and topology of the target manifold directly influence both the dynamics and its controllability, leading to phenomena that do not arise in Euclidean models. This perspective sheds light on small-time global controllability and provides qualitative characterizations, including connections between controllability and homotopy classes.

Based on joint works with Jean-Michel Coron and Joachim Krieger.

A finite element method for phase—field dependent topology optimization in Stokes flow

Yifeng Xu

Shanghai Normal University, China

Abstract: This presentation is concerned with finite element approximations of a phase-field parameterized topology optimization problem governed by the Stokes equations. The discrete minimizing phase field is sought in the usual conforming linear finite element space while the nonconforming linear finite elements (Crouzeix-Raviart elements) and piecewise constants are used to approximate the velocity field and the pressure field respectively. Convergence of the resulting finite element method will be discussed for the uniform and the adaptive mesh refinement strategies respectively. Promising numerical results by the two proposed schemes applied to several examples are also reported. This is a joint work with Prof. Bangti Jin at The Chinese University of Hong Kong, Jing Li and Prof. Shengfeng Zhu, both at East China Normal University.

Hierarchical domain decomposition methods with coarse correction

Hui Zhang

Xi'an Jiaotong-Liverpool University, China

Abstract: We propose a new form of Schwarz methods with coarse correction. First, the coarse basis is generated by the randomized SVD of the interface iteration. Second, we decompose the domain into a hierarchy of subdomains, which resembles nested dissection for constructing direct solvers but with overlap and no separators. The coarse basis is then generated at each level of the hierarchy. The resulting coarse basis is hierarchical and inherently parallel. The ideas are illustrated on the diffusion problem.

Participants' Information

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