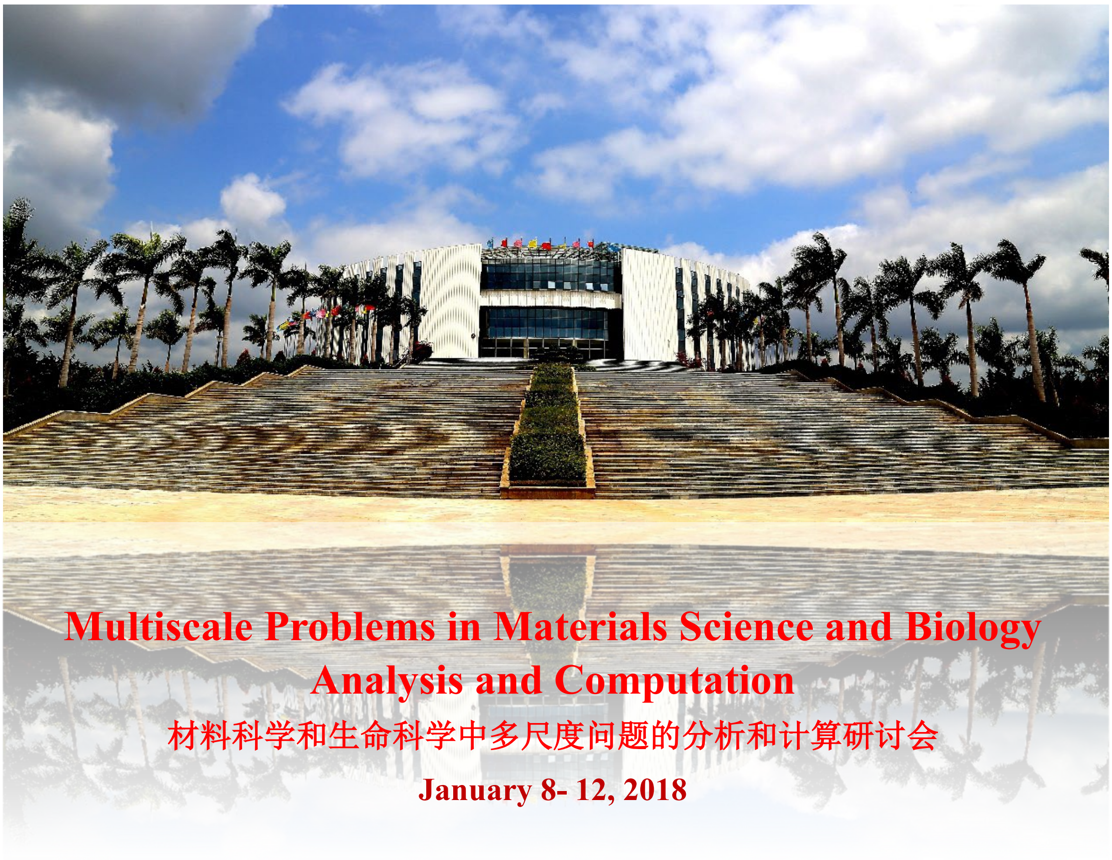


Multiscale Problems in Materials Science and Biology
Analysis and Computation

材料科学和生命科学中多尺度问题的分析和计算研讨会

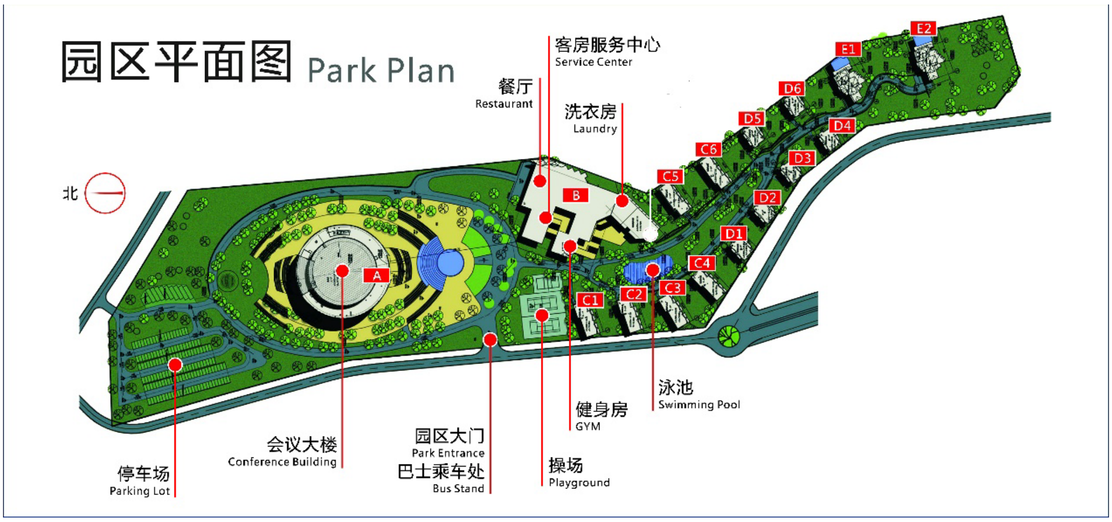
January 8- 12, 2018

Welcome to TSIMF

The facilities of TSIMF are built on a 23-acre land surrounded by pristine environment at Phoenix Hill of Phoenix Township. The total square footage of all the facilities is over 29,000 square meter that includes state-of-the-art conference facilities (over 10,000 square meter) to hold many international workshops simultaneously, two libraries, a guest house (over 10,000 square meter) and the associated catering facilities, a large swimming pool, gym and sports court and other recreational facilities.

Mathematical Sciences Center (MSC) of Tsinghua University, assisted by TSIMF's International Advisory Committee and Scientific Committee, will take charge of the academic and administrative operation of TSIMF. The mission of TSIMF is to become a base for scientific innovations, and for nurturing of innovative human resource; through the interaction between leading mathematicians and core research groups in pure mathematics, applied mathematics, statistics, theoretical physics, applied physics, theoretical biology and other relating disciplines, TSIMF will provide a platform for exploring new directions, developing new methods, nurturing mathematical talents, and working to raise the level of mathematical research in China.

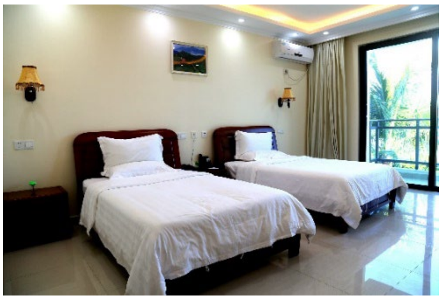
About Facilities



Registration

Conference booklets, room keys and name badges for all participants will be distributed at the Registry. Please take good care of your name badge. It is also your meal card and entrance ticket for all events.

Guest Room



Conference Center can receive about 378 people having both single and double rooms, and 42 family rooms.

All the rooms are equipped with: free Wi-Fi, TV, air conditioning and other utilities

.

Family rooms are also equipped with kitchen and refrigerator.

Library

Opening Hours: 09:00am-22:00pm

TSIMF library is available during the conference and can be accessed by using your room card. There is no need to sign out books but we ask that you kindly return any borrowed books to the book cart in library before your departure.

In order to give readers a better understanding of the contributions made by the Fields Medalists, the library of Tsinghua Sanya International Mathematics Forum (TSIMF) instituted the Special Collection of Fields Medalists as permanent collection of the library to serve the mathematical researchers and readers.
So far, there are 210 books from 43 authors in the Special Collection of Fields Medalists of TSIMF library. They are on display in room A220. The participants are welcome to visit.

Restaurant

All the meals are provided in the Chinese Restaurant (Building B1) according to the time schedule.

Breakfast	07:30-08:30
Lunch	12:00-13:30
Dinner	17:30-19:00

Laundry

Opening Hours: 24 hours

The self-service laundry room is located in the Building 1 (B1).

Gym

The gym is located in the Building 1 (B1), opposite to the reception hall. The gym provides various fitness equipment, as well as pool tables, tennis tables and etc.

Playground

Playground is located on the east of the central gate. There you can play basketball, tennis and badminton. Meanwhile, you can borrow table tennis, basketball, tennis balls and badminton at the reception desk.

Swimming Pool

Please note that there are no lifeguards. We will not be responsible for any accidents or injuries. In case of any injury or any other emergency, please call the reception hall at +86-898-38882828.

Outside Shuttle Service

We have shuttle bus to take participants to the airport for your departure service. Also, we would provide transportation at the Haihong Square （海虹广场） of Howard Johnson for the participants who will stay outside TSIMF. If you have any questions about transportation arrangement, please feel free to contact Ms. Li Ye (叶莉), her cell phone number is (0086)139-7679-8300.

Free Shuttle Bus Service at TSIMF

We provide free shuttle bus for participants and you are always welcome to take our shuttle bus, all you need to do is wave your hands to stop the bus.

Destinations: Conference Building, Reception Room, Restaurant, Swimming Pool, Hotel etc.

Contact Information of Administration Staffs

Location of Conference Affair Office: ***Room 104, Building A***
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Shcedule for Multiscale Problems in Materials Science and Biology Analysis and Computation,January 8- 12, 2018-Room121(33人)					
Time&Date	**Monday (Jan 8)**	**Tuesday (Jan 9)**	**Wednesday (Jan 10)**	**Thursday (Jan 11)**	**Friday (Jan 12)**
7:30-8:30	*Breakfast (60 minutes)*				
Chair					
8:40-9:20	Bo Li	Igor Aranson	Zhiwen Zhang	Xiaoping Wang	
9:20-10:00	Yuan Lou	Hector D.Ceniceros	Spokoiny Vladimir	Eitenne Sandier	
10:00-10:30	*Coffee Break (within 30 minutes)*				
Chair					
10:30-11:10	Tai-Chia Lin	Shi Jin	Leonid Berlyand	Dongzhuo Zhou	
11:10-11:50		Lei Zhang	Zuoqiang Shi		
12:00-13:30	*Lunch (90 minutes)*				
Chair					
13:40-14:20	Zhian Wang	Yalchin Efendiev	Excursion 13:30-17:00	Hao Wu	
14:20-15:00	Min Tang	De Huang		Jiajie Chen	
15:00-15:30	*Coffee Break (within 30 minutes)*			*Coffee Break (within 30 minutes)*	
Chair					
15:30-16:10		Florian Schaefer		Olobatuyi Oluwole	
17:30	*Dinner*		Banquet 18:00-20:00	*Dinner*	

1. Dynamics of topological defects in a living nematic
Igor Aronson, Pennsylvania State University

2. Hierarchy of PDE Models of Cell Motility
Leonid Berlyand, Pennsylvania State University

3. Anisotropic fluids and soft materials: ordered structures, kinetics, and dynamics.
Hector D.Ceniceros, Department of Mathematics, University of California Santa Barbara

4. A pseudo knockoff filter for feature selection of highly correlated variables
Jiajie Chen , California Institute of Technology

5. Generalized multiscale methods for porous media flows and their applications
Yalchin Efendiev, Texas A&M University

6. Energy Decomposition with Applications to Operator Compression and Multiresolution Matrix Decomposition
De Huang , Department of Computing & Mathematical Sciences, California Institute of Technology

7. Stochastic Asymptotic-Preserving Schemes and Hypocoercivity Based Sensitivity Analysis for Multiscale Kinetic Equations with Random Inputs
Shi Jin, Shanghai Jiao Tong University (China) and University of Wisconsin-Madison (USA)

8. Multi-Scale Modeling and Simulation of the Growth of Bacterial Colony with Cell-Cell Mechanical Interactions
Bo Li, Department of Mathematics, UC San Diego

9. Eigenvalue estimate of nonlinear Schrdinger equations with application to photorefractive media
Tai-Chia Lin, National Taiwan University

10. Finding ESS for evolution of movement
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11. The Persistence of Radiation-Induced Bystander Signals
Oluwole Olobatuyi, University of Alberta, Edmonton, AB Canada

12. Two-scale Gamma-convergence and random non-convex ho-

mogenization
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13. Compression, inversion, and approximate PCA of dense kernel matrices at near-linear computational complexity
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14. Interpolation on High Dimensional Point Cloud
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15. Adaptive nonparametric clustering
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16. The role of intracellular signaling in the stripe formation in engineered E. coli populations
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17. Contact line behavior of the threshold dynamics method for interface motion
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19. Variational approach for Markov processes
Hao Wu, Institute of Mathematics, Freie Universit Berlin

20. Phase field modeling of Cell Polarity and Cell Delamination
Lei Zhang, Beijing International Center for Mathematical Research, Center for Quantitative Biology, Peking University

21. A model reduction method for stochastic multiscale elliptic PDEs using an optimization approach
Zhiwen Zhang, Hong Kong University

22. Hazards in data analysis of biological experiments
Douglas Zhou, Institute of Natural Sciences & School of Mathematical Sciences, Shanghai Jiao Tong University

1. Dynamics of topological defects in a living nematic

Igor Aronson, Pennsylvania State University

Living nematic is a realization of an active matter combining a nematic liquid crystal with swimming bacteria. The material exhibits remarkable tendency towards spatio-temporal self-organization manifested in formation of dynamics textures of self-propelled half-integer topological defects (disclinations). Here, by coupling the well-established and validated PDE model of nematic liquid crystals with the conservation laws for bacterial dynamics, we develop a computational model describing intricate properties of such a living nematic. The model yielded a testable prediction on the accumulation of bacteria in the cores of 1/2 topological defects and depletion of bacteria in the cores of -1/2 defects. We also studied of such living nematic near normal inclusions, or tactoids, naturally realized in liquid crystals close to the isotropic-nematic (I-N) phase transition. On the basis of computational analysis, we have established that tactoid's I-N interface spontaneously acquire negative topological charge which is proportional to the tactoid's size and depends on the concentration of bacteria. The observed negative charging is attributed to the drastic difference in the mobilities of 1/2 and -1/2 topological defects in active systems. The effect is described in the framework of a kinetic theory for point-like weakly-interacting defects with different mobilities. Our dedicated experiments fully confirmed both theoretical predictions. The results hint into new strategies for control of active matter.

2. Hierarchy of PDE Models of Cell Motility

Leonid Berlyand, Pennsylvania State University

We consider mathematical PDE models of motility of eukaryotic cells on a substrate and discuss them in a broader context of active materials. Our goal is to capture mathematically the key biological phenomena such as steady motion with no external stimuli and spontaneous breaking of symmetry.
We first describe the hierarchy of PDE models of cell motility and then focus on two specific models: the phase-field model and the free boundary problem model.
The phase-field model consists of the Allen-Cahn equation for the scalar phase field function coupled with a vectorial parabolic equation for the orientation of the actin filament network. The key mathematical properties of this system are (i) the presence of gradients in the coupling terms and (ii) the mass (volume) preservation constraints. These properties lead to mathematical challenges that are specific to active (out of equilibrium) systems, e.g., the fact that variational principles do not apply. Therefore, standard techniques based on maximum principle and Gamma-convergence cannot be used, and one has to develop alternative asymptotic techniques.
The free boundary problem model consists of an elliptic equation describing the flow of the cytoskeleton gel coupled with a convection-diffusion PDE for the density of myosin motors. This PDE system is of Keller-Segel type but in a free boundary setting with nonlocal

condition that involves boundary curvature. Analysis of this system allows for a reduction to a Liouville type equation which arises in various applications ranging from geometry to chemotaxis. This equation contains an additional term that presents an additional challenge in analysis.

In the analysis of the above models our focus is on establishing the traveling wave solutions that are the signature of the cell motility. We also study breaking of symmetry by proving existence of non-radial steady states. Bifurcation of traveling waves from steady states is established via the Schauder's fixed point theorem for the phase field model and the Leray-Schauder degree theory for the free boundary problem model.

These results are obtained in collaboration with J. Fuhrmann, M. Potomkin, and V. Rybalko.

3. Anisotropic fluids and soft materials: ordered structures, kinetics, and dynamics.

Hector D.Ceniceros, Department of Mathematics, University of California Santa Barbara

"Anisotropic fluids and soft materials are characterized by a microscopic or nanoscopic component which exhibits an average preferential orientation at equilibrium. Liquid crystals, liquid crystalline polymers, and magnetic fluids are premier examples of this type of material. Local microscopic orientation at both free and solid boundaries leads to global distortions of an orientational field with long-ranged effects that ultimately produce ordered structures and macroscopic changes in the soft material. We will discuss some of the significant challenges in the mathematical modeling and computation of this important multiscale problem and will present results of our numerical investigations of phase separation of mixtures with a liquid crystalline component and on magnetic fluids."

4. A pseudo knockoff filter for feature selection of highly correlated variables

Jiajie Chen, California Institute of Technology

In many applications, we need to study a linear regression model that consists of a response variable and a large number of potential explanatory variables and determine which variables are truly associated with the response. The knockoff procedure recently introduced by Barber and Candes is able to discover these variables effectively while controlling the false discovery rate (FDR)the expected fraction of false discoveries among all discoveries. It has been demonstrated that when the proportion of null variables is high, this method has more power (the proportion of true discoveries) than existing selection rules that offer some FDR control.

We propose three classes of pseudo knockoff filter, namely orthogonal pseudo knockoff, block diagonal and banded knockoff that inherit the advantage of the original knockoff filter and has more flexibility in constructing its knockoff matrix. Meanwhile, we will discuss the result about FDR control and show that it has more power than the original knockoff when the

variables are highly correlated and non-sparse. We will also briefly talk about its application in a HIV dataset.
This is joint work with Anthony Hou and Thomas Hou.

5. Generalized multiscale methods for porous media flows and their applications

Yalchin Efendiev, Texas A&M University

Subsurface formations often display high degrees of variability over multiple length scales. This permeability's spatial variations and complex connectivity impact flow and transport. For this reason, these effects must be included in simulations of flows. Upscaling techniques are introduced to coarsen these geological models for flow calculations. The main idea of upscaling techniques is to formulate macroscopic equations on a coarse grid and ways to compute macroscopic parameters.It is important that these coarsened flow models replicate the fine scale characterizations. Recently, multiscale methods are introduced to perform coarse-grid simulations. In this talk, I will give an overview of some multiscale methods and discuss their relation to flow-based upscaling. I will mostly focus on single-phase flow and show how to derive upscaled models and compute effective properties using multiscale methods and flow-based upscaling. I will describe subgrid errors in these methods and show a relation between multiscale methods and flow-based upscaling methods, including multi-continuum theories. Then, I will describe a general multiscale framework and show how one can achieve an accurate coarse-grid models using multi-continuum and non-local upscaling. I will describe some applications of multiscale methods to Bayesian approaches and inverse problems.

6. Energy Decomposition with Applications to Operator Compression and Multiresolution Matrix Decomposition

De Huang , Department of Computing & Mathematical Sciences California Institute of Technology

In this talk, we propose an adaptive fast solver for a general class of symmetric positive definite (SPD) matrices which include the well-known graph Laplacian. We achieve this by developing an adaptive operator compression scheme and a multiresolution matrix factorization algorithm which achieve nearly optimal performance on both complexity and well-posedness. To develop our adaptive operator compression and multiresolution matrix factorization methods, we first introduce a novel notion of **energy decomposition** for SPD matrix A using the representation of energy elements. The interaction between these energy elements depicts the underlying topological structure of the operator. This concept of decomposition naturally reflects the hidden geometric structure of the operator which inherits the localities of the structure. By utilizing the intrinsic geometric information under this Energy framework, we propose a systematic operator compression scheme for the inverse operator A^{-1}. In particular, with an *appropriate partition* of the underlying geometric structure, we can construct localized basis by using the concept of **interior** and **closed energy**. Meanwhile, two important localized quantities are introduced, namely the **error factor** and the **condition factor**. Our error analysis results show that these two factors will be the guidelines for finding the appropriate partition of the basis functions such that prescribed compression error and acceptable condition number can be achieved. By virtue of this insight, we propose the **Patch Pairing** algorithm to realize our energy partition framework for operator compression with controllable compression error and condition number.

7. Stochastic Asymptotic-Preserving Schemes and Hypocoercivity Based Sensitivity Analysis for Multiscale Kinetic Equations with Random Inputs

Shi Jin, Shanghai Jiao Tong University, China and University of Wisconsin-Madison, USA

In this talk we will study kinetic equations with multiple scales and random uncertainties from initial data and/or collision kernel. Here the multiple scales, characterized by the Knudsen number, will lead the kinetic equations to hydrodynamic (Euler, incompressible Navier-Stokes or diffusion) equations as the Knudsen number goes to zero. Asymptotic-preserving schemes, which minic the asymptotic transitions from the microscopic to the macroscopic scales at the discrete level, have been shown to be effective to deal with multiscale problems in the deterministic setting.
We first extend the prodigm of asymptotic-preserving schemes to the random kinetic equations, and show how it can be constructed in the setting of the stochastic Galerkin approximations. We then extend the hypocoercivity theory, developed for deterministic kinetic equations, to the random case, and establish in the random space regularity, long-time sensitivity analysis, and uniform (in Knudsen number) spectral convergence of the stochastic Galerkin methods, for general lienar and nonlinear random kinetic equations in various asymptotic–including the duffusion, incompressible Navier-Stokes, high-field, and acoustic–regimes.

8. Multi-Scale Modeling and Simulation of the Growth of Bacterial Colony with Cell-Cell Mechanical Interactions

Bo Li, Department of Mathematics UC San Diego

The growth of bacterial colony exhibits striking patterns that are determined by the interactions among individual, growing and dividing bacterial cells, and that between cells and the surrounding nutrient and waste. Understanding the principles that underlie such growth has far-reaching consequences in biological and health sciences. In this work, we construct a multi-scale model of the growth of E. coli cells on agar surface. Our model consists of detailed, microscopic descriptions of the cell growth, cell division with fluctuations, and cell movement due to the cell-cell and cell-environment mechanical interactions, and macroscopic diffusion equations for the nutrient and waste. We use the velocity Verlet algorithm to simulate the motion of individual cells and iterative algorithm to update the nutrient. Our large-scale simulations reproduce experimentally observed growth scaling laws, strip patterns, and many other features of an E. coli colony. This work is the first step toward detailed multi-scale computational modeling of three-dimensional bacterial growth with mechanical and chemical interactions. This is joint work with Mya Warren, Hui Sun, Yue Yan, and Terry Hwa.

9. Eigenvalue estimate of nonlinear Schrdinger equations with application to photorefractive media

Tai-Chia Lin, National Taiwan University

"The virial theorem is a nice property for the linear Schrödinger equation in atomic and molecular physics as it gives an elegant ratio between the kinetic and potential energies and is useful in assessing the quality of numerically computed eigenvalues. If the governing equation is a nonlinear Schrödinger equation with power-law nonlinearity, then a similar ratio can be obtained but there seems no way of getting any eigenvalue estimate. It is surprising as far as we are concerned that when the nonlinearity is either square root or saturable nonlinearity (not a power-law), one can develop a virial theorem and eigenvalue estimate of nonlinear Schrödinger (NLS) equations in R2 with square root and saturable nonlinearity, , which describe photorefractive media, narrow-gap semiconductors and graphene metamaterials. Furthermore, the eigenvalue estimate can be used to prove the 2nd order term (which is of order $\ln \Gamma$) of the lower bound of the ground state energy as the coefficient Γ of the nonlinear term tends to infinity."

10. Finding ESS for evolution of movement

Yuan Lou, Ohio State University

"To study the evolution of movement we study the Perthame-Souganidis mutation-selection model and its extensions. These are integro-PDE models for a population structured by the spatial variables and one trait variable. Competition for resource is local in spatial variables, but nonlocal in the trait variable. Under proper conditions on the invasion fitness gradient, we show that in the limit of small mutation rate, the positive steady state solution will concentrate in the trait variable and forms one or two Dirac masses . Biologically this suggests that either a single strategy is evolutionarily stable or two strategies as a pair can be evolutionarily stable and resist the invasion of other strategies. This talk is based on joint works with King-Yeung Lam (Ohio State) and Wenrui Hao (Penn State)."

11. The Persistence of Radiation-Induced Bystander Signals

Oluwole Olobatuyi, University of Alberta, Edmonton, AB Canada

In experimental studies, it has been found that when certain cell lines are exposed to low-dose of radiation, they transmit bystander signals to the surrounding unirradiated cells. In response to these signals, the unirradiated cells exhibit radiation-induced symptoms (also called bystander effects). In fact, this phenomenon has been associated with the hyper-radiosensitivity exhibited by certain cells under low doses of radiation. The underlying dynamics of this low-dose phenomenon is still poorly understood and there are open questions relating to the persistence of this signals as well as their invasion into the surrounding un-irradiated environment. Whereas Mothersill and Seymour (1997) found that an emitted bystander signal can still trigger bystander effects in cells even 60h after its emission. Other experiments, including the data from the Hiroshima and Nagasaki survivors, have shown that the signal can persist for months and even years. Here, we develop and analyze a reaction-diffusion model to investigate the persistence and invasion of these signals. We fit the model to a surviving fraction data on hyper-radiosensitivity to validate the model and estimate some of the model's parameters. Furthermore, we use phase plane analysis to understand the full dynamics of the signal's lifespan. We find that both single and multiple radiation exposures can lead to bystander signals that either persists temporarily or permanently. We also found that, in an heterogenous environment, the size of the domain exposed to radiation and the number of radiation exposures can determine whether a signal will persist temporarily or permanently. Finally, we will discuss some recent results on the traveling wave solution of this model.

12. Two-scale Gamma-convergence and random non-convex homogenization

Etienne Sandier, Université Paris-Est Créteil

In this joint work with L.Berlyand and S.Serfaty, we bring together approaches of Dal Maso-Modica and Alberti-Müller to provide a theoretical framework we believe to be efficient for the analysis of multiscale problems, especially non-convex ones. As a test we apply it to a random version of a 1-D problem studied by Alberti-Müller.

13. Compression, inversion, and approximate PCA of dense kernel matrices at near-linear computational complexity

Florian Schäfer, Caltech

Many popular methods in machine learning, statistics, and uncertainty quantification rely on priors given by smooth Gaussian processes, like those obtained from the Matérn covariance functions. Furthermore, many physical systems are described in terms of elliptic partial differential equations. Therefore, implicitly or explicitly, numerical simulation of these systems requires an efficient numerical representation of the corresponding Greens operator.
The resulting kernel matrices are typically dense, leading to (often prohibitive) $O(N^2)$

or $O(N^3)$ computational complexity. In this work, we prove rigorously that the dense $N \times N$ kernel matrices obtained from elliptic boundary value problems and measurement points distributed approximately uniformly in a d-dimensional domain can be Cholesky factorized to accuracy ϵ in computational complexity $O\big(N \log^2(N) \log^{2d}(N/\epsilon)\big)$ in time and $O\big(N \log(N) \log^{d}(N/\epsilon)\big)$ in space.
For the closely related Matérn covariances we observe very good results in practice, even for parameters corresponding to non-integer order equations. As a byproduct, we obtain a sparse PCA with near-optimal low rank approximation property and a fast solver for elliptic PDE. We emphasize that our algorithm requires no analytic expression for the covariance function.
Our work connects the probabilistic interpretation of the Cholesky factorization, the screening effect in spatial statistics, and numerical homogenization. In particular, results from the game theoretic approach to numerical analysis (Gamblets) allow us obtain rigorous error estimates.

14. Interpolation on High Dimensional Point Cloud

Zuoqiang Shi, Tsinghua University

Interpolation on high dimensional point cloud provides a fundamental model in many data analysis and machine learning problems.
In this talk, we will present some PDE based methods to do interpolation on point cloud. Applications in image processing and data analysis are shown to demonstrate the performance of our methods.

15. Adaptive nonparametric clustering

Vladimir Spokoiny , Weierstrass Institute and Humboldt University Berlin

This paper presents a new approach to non-parametric cluster analysis called Adaptive Weights Clustering (AWC). The idea is to identify the clustering structure by checking at different points and for different scales on departure from local homogeneity. The proposed procedure describes the clustering structure in terms of weights w_{ij} each of them measures the degree of local inhomogeneity for two neighbor local clusters using statistical tests of "no gap" between them. The procedure starts from very local scale, then the parameter of locality grows by some factor at each step. The method is fully adaptive and does not require to specify the number of clusters or their structure. The clustering results are not sensitive to noise and outliers, the procedure is able to recover different clusters with sharp edges or manifold structure. The method is scalable and computationally feasible. Our intensive numerical study shows a state-of-the-art performance of the method in various artificial examples and applications to text data. We also provide a rigorous theoretical study of the procedure and state its optimal sensitivity to deviations from local homogeneity. Further we discuss an extension of the proposed approach based on a multiscale no gap test to network clustering.

16. The role of intracellular signaling in the stripe formation in engineered E. coli populations

Min Tang, School of Mathematics and Institute of Natural Sciences, Shanghai Jiao Tong University, Shanghai, China

Recent experiments showed that engineered *Escherichia coli* colonies grow and self-organize into periodic stripes with high and low cell densities in semi-solid agar. The stripes establish sequentially behind a radially propagating colony front, similar to the formation of many other periodic patterns in nature. These bacteria were created by genetically coupling the intracellular chemotaxis pathway of wild-type cells with a quorum sensing module through the chemotaxis protein CheZ. Despite the direct involvement of the chemotaxis pathway in these experiments, how chemotaxis contribute to the stripe formation and how the intracellular pathway affect the pattern have yet been investigated systematically. To address this problem, we developed multi-scale models that incorporate key molecular mechanisms of chemotaxis and quorum sensing and used them to investigate the role of intracellular signaling in the population dynamics. We first developed a hybrid model that treats each cell as a particle that move and respond to the quorum sensing signal, AHL. The hybrid model is amenable to integrate the molecular details of intracellular signaling, but is computationally expensive in higher space dimensions. To address the computational challenge, we then derived a mean-field PDE model from the hybrid model using asymptotic analysis. The analysis is justified by the tight agreement of the PDE model and the hybrid model in 1D simulations under different parameter regimes, either with or without the formation of stripes. Numerical simulations of the PDE model in 2D with radial symmetry agree with experiments semi-quantitatively. In order to understand how the pattern depends on individual cell traits, the PDE model is then used to make a number of predictions. We alter the cell velocity, doubling time or the turn over rate of CheZ, and explore the variances of the stripe pattern.

17. Contact line behavior of the threshold dynamics method for interface motion

Xiaoping Wang, Hong Kong University of Science and Technology

We study the contact line behavior of the threshold dynamics method we developed in the previous work. Asymptotic analysis is performed to show that one obtains correct contact angle (Youngs angle) in the leading order by choosing different Gaussian kernel variance properly. We then propose an improved threshold dynamics method for wetting dynamics. The method is based on the minimization of the weighted interface area functional over an extended domain that includes the solid phase. Each interface area is approximated by the

Lyapunov functional with a different Gaussian kernel. We show that the method is unconditionally stable.

18. Kinetic models of chemotaxis with temporal sensing mechanism: the parabolic limit and its dynamics

Zhian Wang, Department of Applied Mathematics, Hong Kong Polytechnic University

Abstract: It is well-known that the Keller-Segel type chemotaxis system can be derived as the parabolic limit of the kinetic model describing the velocity-jump process. When the tumbling kernel depends on the temporal gradient of chemical concentration, the rigorous parabolic limit of the kinetic model has not been completely understood. In this talk, we shall report a result for such scenario where the tumbling kernel depending on temporal gradient of chemical concentration is a decreasing smoothed stiff signal response function. We show that parabolic limit of the kinetic model with such tumbling kernel will result in a flux-limited chemotaxis system, which has some distinct features than the classical Keller-Segel model.

19. Variational approach for Markov processes

Hao Wu, Institute of Mathematics, Freie Universit

In this talk, we introduce a variational approach for Markov processes (VAMP) that allows us to find optimal feature mappings and optimal Markovian models of the dynamics from given time series data. The key insight is that the best linear model can be obtained from the top singular components of the Koopman operator. This leads to the definition of a family of score functions called VAMP-r which can be calculated from data, and can be employed to optimize a Markovian model. In addition, based on the relationship between the variational scores and approximation errors of Koopman operators, we propose a new VAMP-E score, which can be applied to cross-validation for hyper-parameter optimization and model selection in VAMP. VAMP is valid for both reversible and nonreversible processes and for stationary and non-stationary processes or realizations.

20. Phase field modeling of Cell Polarity and Cell Delamination

Lei Zhang, Beijing International Center for Mathematical Research, Center for Quantitative Biology, Peking University

Control of cellular behaviors plays a critical role in pattern formation, growth regulation and regeneration. Numerous developmental processes have been extensively studied from a mechanistic perspective, but only recently have serious efforts been directed toward systems biology approach. In this talk, I will present two biological systems to study pattern formation by using phase field model. First, we present a mathematical model that incorporates the interplays between Rac, filamentous actin (F-actin), and membrane tension for the formation of cell polarity. Second, I present a phase field approach to study the neuroblast delamination in Drosophila. Dynamics of cell ingression and role of actin-myosin network in apical constriction reveal that the myosin signaling drives neuroblast delaminiation in such rare event. The joint work with Feng Liu (PKU), Yan Yan (HKUST).

21. A model reduction method for stochastic multiscale elliptic PDEs using an optimization approach

Zhiwen Zhang, Hong Kong University

We propose a model reduction method for solving stochastic multiscale elliptic PDEs using an optimization approach. The optimization approach enables us to construct a set of localized multiscale data-driven stochastic basis functions that give optimal approximation property of the solution operator. Our method consists of offline and online stages. In the offline stage, we construct the localized multiscale data-driven stochastic basis functions by solving an optimization problem. In the online stage, using our basis functions, we can efficiently solve stochastic multiscale elliptic PDEs with relatively small computational costs. Therefore, our method is very efficient in solving stochastic multiscale elliptic PDEs with many different force functions. The convergence analysis of the proposed method is also presented and has been verified by numerical simulations.

22. Hazards in data analysis of biological experiments

Douglas Zhou, Institute of Natural Sciences & School of Mathematical Sciences, Shanghai Jiao Tong University

Most of dynamical processes are continuous, whereas in experiment, signals are often measured in the form of discrete spatiotemporal series and conclusions are drawn by analyzing these sampled signals. In this talk, We will use two examples to illustrate how different samplings may lead to artifacts of data processing and discuss how to circumvent these problems. The first example is the analysis of spatiotemporal activities measured by voltage-sensitive-dye-based optical imaging in the primary visual cortex of the awake monkey. Through a large-scale computational modeling, we demonstrate that our model can well capture the phenomena observed in experiment and can separate real physiological signals from statistical artifacts arising from spatial averaging procedures in experiment. The second example is the application of Granger causality to infer information flow within continuous dynamical processes. We describe how certain sampling rate may potentially yield incorrect causal inferences. These sampling artifacts can be present in both linear and nonlinear processes. Such hazards can give rise to incorrect network reconstructions using causal inferences. We will provide a strategy to obtain a reliable Granger causality inference.