International Workshop on Nonlinear Partial Differential Equations and Scientific Computing

July 5 –8, 2016

Fragrant Hill Hotel, Beijing, China

http://www.csrc.ac.cn/en/event/workshop/2016-02-17/60.html

Sponsorship: Beijing Computational Science Research Center

Beijing University of Technology

Capital Normal University

Contents

Information for Participants

Conference Hotel for Invited Speakers

Hotel:	Fragrant Hill Hotel 香山饭店
Address:	Fragrant Hill Park, Haidian District, Beijing 100093, China 北京市海淀区买卖街 40 号（香山公园内）
Dates:	By default, the hotel room is reserved based on your confirmed arrival/departure time. The conference ends at July 8th. For those leaving Beijing on July 10th or after, from July 8th to your departure date, we will reserve you a room in "Holiday Inn Express Shangdi Beijing" (北京上地智选假日酒店), Address: No. 33 Shangdi East Road, Haidian District, Beijing (北京市海淀区上地东路 33 号) Telephone: +86-10-82709999 / 400-830-2360 .
Arrival:	By air, see this link. Address information in the last pages.
Website:	http://www.fragrant-hill.com/index.html
Tel:	400-636-6636

Conference Venue

For July 5, 7 & 8:	Multi-purpose Hall, 2nd floor, Fragrant Hill Hotel 香山饭店二层多功能厅
For July 6:	Conference room II, CSRC 北京计算科学研究中心，第二会议室

Meals

- Breakfasts will be complementary at the hotel.
- Lunches and dinners are provided by the workshop. Please let us know if you have any dietary restrictions or preferences.

Introduction

Nonlinear partial differential equations (PDEs) arise in many areas of applied sciences. Analysis and simulation are two basic tools for the study of nonlinear PDEs. This workshop will bring applied and computational as well as pure mathematicians together to exchange the latest developments in the study of nonlinear PDEs and scientific computing, identify future directions and unsolved questions, and actively initiate collaborations. The workshop also provides an opportunity for local graduate students and junior researchers to learn the state-of-the-art knowledge in nonlinear PDEs and scientific computing as well as their applications.

Organizing Committee

Weizhu BAO	National University of Singapore and Beijing Computational Science Research Center
Hailiang LI (Chair)	Capital Normal University
Shu WANG	Beijing University of Technology

Invited Speakers

Uri Ascher	University of British Columbia, Canada
Yongyong Cai	Beijing Computational Science Research Center, China
Ionut Danaila	University De Rouen, France
Bertram Duering	University of Sussex, UK
Yalchin Efendiev	Texas A&M University, USA
Heinz Engl	University of Vienna, Austria
Klemens Fellner	University of Graz, Austria
Ingenuin Gasser	Universitat Hamburg, Germany
Diogo Gomes	KAUST, Saudi Arabia
Zhongyi Huang	Tsinghua University, China
Song Jiang	Institute of Applied Physics and Computational Mathematics, China
Christian Klein	Institut de Mathématiques de Bourgogne, Université de Bourgogne
Alexander Lorz	Université Pierre Marie Curie, France
Pierangelo Marcati	University of L'Aquila, Italy
Paul A Milewski	University of Bath, UK
Lorenzo Pareschi	University of Ferrara, Italy
Benoit Perthame	Laboratoire J.-L. Lions, Universite P.et M. Curie, CNRS, INRIA-Paris
Paola Pietra	CNR at Pavia, Italy
Carola Schoenlieb	University of Cambridge, UK
Christian Schmeiser	University of Vienna, Austria
Henrik Shagholian	Kungliga Tekniska högskolan, Sweden

Schedule Overview

July 4, 2016 (Monday)
Venue: Fragrant Hill Hotel, Beijing, China

3:00 - 6:00	Registration
6:00	Dinner

July 5, 2016 (Tuesday)
Venue: Fragrant Hill Hotel, Beijing, China

8:30 - 9:00	Registration
9:00 - 9:10	Opening Remarks by Organizers
9:10 - 9:40	Pierangelo Marcati
9:40 - 10:10	Qi Wang
10:10 - 10:40	Coffee & Tea Break
10:40 - 11:10	Tong Yang
11:10 - 11:40	Bertram Duering
11:40 - 12:10	Christian Schmeiser
12:10 - 2:00	Lunch
2:00 - 2:30	Song Jiang
2:30 - 3:00	Jorge Zubelli
3:00 -3:30	Saber Trabelsi
3:00 - 4:00	Coffee & Tea Break
4:00 - 4:30	Ionut Danaila
4:30 - 5:00	Zhongyi Huang
5:00 - 5:30	Yongyong Cai
6:00 - 8:00	Dinner

Remarks:

1. All talks will be held in the conference room at the Fragrant Hill Hotel except July 6 (Wednesday) which will be held at Beijing Computational Science Research Center (CSRC).
2. On July 6, a bus will leave from the Fragrant Hill Hotel at 8:30am to take all participants to Beijing CSRC. Also, a bus will leave from Beijing CSRC to the banquet at 5:30pm. After the banquet, the bus will take all participants back to the Fragrant Hill Hotel.
3. For those who arrive on July 6 (Wednesday), you can either come to Beijing CSRC directly or check-in the hotel and then come to Beijing CSRC.

July 6, 2016 (Wednesday)
Venue: At Beijing Computational Science Research Center (CSRC)

8:30	Bus leaves from the Fragrant Hill Hotel
9:30 - 10:00	Athanasis Tzavaras
10:00 - 10:30	Henrik Shagholian
10:30 - 11:00	Coffee & Tea Break
11:00 - 11:30	Yalchin Efendiev
11:30 - 12:00	Lorenzo Pareschi
12:00 - 12:30	Paul A Milewski
12:30 - 2:00	Lunch at CSRC
2:00 - 2:30	Ping Zhang
2:30 - 3:00	Alexander Lorz
3:00 - 3:30	Diogo Gomes
3:30 - 4:00	Coffee & Tea Break
4:00 - 4:30	Paola Pietra
4:30 - 5:00	Chunxiong Zheng
5:00 - 5:30	Christian Klein
5:35	Bus leaves from CSRC to banquet restaurant
6:30 - 9:00	Banquet Special Banquet Speech by Heinz Engl

Remarks:

Free Wi-Fi: csrc_guest, password: csrc20150308

July 7, 2016 (Thursday)
Fragrant Hill Hotel, Beijing, China

8:30 - 9:00	Registration
9:00 - 9:30	Zhouping Xin
9:30 - 10:00	Jie Shen
10:00 - 10:30	Coffee & Tea Break
10:30 - 11:00	Benoit Perthame
11:00 - 11:30	Ingenuin Gasser
11:30 - 12:00	Klemens Fellner
12:00 - 1:30	Lunch
1:30 - 6:00	Social tour (volunteer and self-paid) – A bus will leave at 1:30pm to City
6:30 - 8:30	Dinner

July 8, 2016 (Friday)
Fragrant Hill Hotel, Beijing, China

8:30 -9:00	Registration
9:00 - 9:30	Takis Souganidis
9:30 - 10:00	Kaijun Zhang
10:00 - 10:30	Marie-Therese Wolfram
10:30 -11:00	Coffee & Tea Break
11:00 -11:30	Uri Ascher
11:30 -12:00	Carola Schoenlieb
12:00 -12:30	Qinglin Tang
12:30 - 12:40	Closing Remarks by Organizers
12:40 - 2:00	Lunch

Schedule with Titles of Talks

July 5, 2016 (Tuesday)
Venue: Fragrant Hill Hotel, Beijing, China

8:30 - 9:00	Registration
9:00 - 9:10	Opening Remarks by Organizers
9:10 - 9:40	**Pierangelo Marcati** Mathematical problems for the quantum hydrodynamic systems in superfluidity and other applications
9:40 - 10:10	**Qi Wang** Energy stable numerical methods for dissipative partial differential equation systems
10:10 - 10:40	Coffee & Tea Break
10:40 - 11:10	**Tong Yang** Measure valued solutions to the boltzmann equation
11:10 - 11:40	**Bertram Duering** Inhomogeneous Boltzmann-type equations modelling opinion leadership and political segregation
11:40 - 12:10	**Christian Schmeiser** The filament based lamellipodium model (FBLM)
12:10 - 2:00	Lunch
2:00 - 2:30	**Song Jiang** On stabilizing effect of the magnetic field in the magnetic Rayleigh-Taylor problem
2:30 - 3:00	**Jorge Zubelli** A non-intrusive stratified resampler for regression Monte Carlo
3:00 -3:30	**Saber Trabelsi** Continuous data assimilation for the three-dimensional Brinkman-Forchheimer-extended Darcy Model
3:00 - 4:00	Coffee & Tea Break
4:00 - 4:30	**Ionut Danaila** Finite-element tools for the simulation of Bose-Einstein condensates
4:30 - 5:00	**Zhongyi Huang** Bloch decomposition based method for quantum dynamics in periodic media
5:00 - 5:30	**Yongyong Cai** Numerical methods for the Dirac equation in the non-relativistic limit regime
6:00 - 8:00	Dinner

July 6, 2016 (Wednesday)
Venue:At Beijing Computational Science Research Center (CSRC)

8:30	Bus leaves from the Fragrant Hill Hotel
9:30 - 10:00	**Athanasis Tzavaras** The relative entropy method; connection with the second law and variational structures
10:00 - 10:30	**Henrik Shagholian** Regularity of solutions to "Broken" PDEs
10:30 - 11:00	Coffee & Tea Break
11:00 - 11:30	**Yalchin Efendiev** A generalized multiscale model reduction technique for heterogeneous problems
11:30 - 12:00	**Lorenzo Pareschi** Numerical techniques for mean-field equations of collective behavior with uncertainties
12:00 - 12:30	**Paul A Milewski** Modelling and computation of a fluid experiment with quantum-like behavior
12:30 - 2:00	Lunch at CSRC
2:00 - 2:30	**Ping Zhang** Global regularities of two-dimensional density patch for inhomogeneous incompressible viscous flow with general density
2:30 - 3:00	**Alexander Lorz** On a Boltzmann mean field model for knowledge growth
3:00 - 3:30	**Diogo Gomes** Recent progresses in the theory of mean-field games
3:30 - 4:00	Coffee & Tea Break
4:00 - 4:30	**Paola Pietra** A plane wave virtual element method for the Helmholtz problem
4:30 - 5:00	**Chunxiong Zheng** Extended WKB analysis for high frequency wave equations
5:00 - 5:30	**Christian Klein** Multidomain spectral method for Schrödinger equations
5:35	Bus leaves from CSRC
6:30 - 9:00	Banquet Guest-of-honor and speaker: Professor Heinz Engl, University of Vienna

July 7, 2016 (Thursday)
Fragrant Hill Hotel, Beijing, China

8:30 - 9:00	Registration
9:00 - 9:30	**Zhouping Xin** Nonlinear asymptotic stability of the Lane-Emden solution for the viscous gaseous star problem
9:30 - 10:00	**Jie Shen** Efficient spectral methods for solving a class of fractional PDEs in unbounded domains
10:00 - 10:30	Coffee & Tea Break
10:30 - 11:00	**Benoit Perthame** PDE models of natural networks
11:00 - 11:30	**Ingenuin Gasser** On the existence of rarefaction shock waves
11:30 - 12:00	**Klemens Fellner** How duality gives long live to solutions and why entropy agrees with it
12:00 - 1:30	Lunch
1:30 - 6:00	Social tour (volunteer and self-paid) – A bus will leave at 1:30pm to City
6:30 - 8:30	Dinner

July 8, 2016 (Friday)
Fragrant Hill Hotel, Beijing, China

8:30 -9:00	Registration
9:00 - 9:30	**Takis Souganidis** Scalar conservation laws with rough time dependence
9:30 - 10:00	**Kaijun Zhang** Existence and stability of the stationary solution to the compressible Navier-Stokes-Poisson equations in a half line
10:00 - 10:30	**Marie-Therese Wolfram** Price formation: from Boltzmann to mean field models
10:30 -11:00	Coffee & Tea Break
11:00 -11:30	**Uri Ascher** Physics-based soft object deformation: model calibration and motion simulation
11:30 -12:00	**Carola Schoenlieb** Customising image analysis using nonlinear partial differential equations
12:00 -12:30	**Qinglin Tang** Efficient and accurate numerical methods for computing the ground states and dynamics of spin 2 Bose-Einstein condensates
12:30 - 12:40	Closing Remarks by Organizers
12:40 - 2:00	Lunch

Titles and Abstracts

Physics-based soft object deformation: model calibration and motion simulation

Uri Ascher

University of British Columbia, Canada

Abstract

Motion simulation of soft objects such as cloth, plants and some body parts is ubiquitous in computer graphics and robotics applications. The governing elastodynamics PDE system is often discretized in space already at the variational level, using FEM. This leads to a large, expensive to assemble, ODE system in time, where the damped motion may mask highly oscillatory stiffness. The model described by the differential system must be calibrated first. We present a data-driven method for this inverse problem. An iterative splitting framework is adopted that consists of one component for physics based deformation tracking and another for space-time optimization of a set of deformation parameters including Young's moduli and damping coefficients. Low cost depth sensors are used for the deformation capture, and we do not require any force-displacement measurements, thus making the data capture a cheap and convenient process. A state-of-the-art probabilistic tracking method is augmented to robustly handle noise, occlusions, fast movements and large deformations. The space-time optimization aims to match the simulated trajectories with the tracked ones. The optimized deformation model is then used to boost the accuracy of the tracking results, which can in turn improve the deformation parameter estimation itself in later iterations. Numerical experiments demonstrate that the tracking and parameter optimization components complement each other nicely. A semi-implicit time integration method is employed, and this introduces artificial damping. I will show a simple analysis of this effect and discuss its implications. Our results shall all be demonstrated, of course. This talk is based on joint works with Bin Wang, Longhua Wu, KangKang Yin, Libin Liu & Hui Huang ('15), and Edwin Chen & Dinesh Pai ('16).

Numerical methods for the Dirac equation in the non-relativistic limit regime

Yongyong Cai

Beijing Computational Science Research Center, China

Abstract

Dirac equation, proposed by Paul Dirac in 1928, is a relativistic version of the Schroedinger equation for quantum mechanics. It describes the evolution of spin-1/2 massive particles, e.g. electrons. Due to its applications in graphene and 2D materials, Dirac equations has drawn considerable interests recently. We are concerned with the numerical methods for solving the Dirac equation in the non-relativistic limit regime, involving a small parameter inversely proportional to the speed of light. We begin with commonly used numerical methods in literature, including finite difference time domain and time splitting spectral, which need very small time steps to solve the Dirac equation in the non-relativistic limit regime. We then propose and analyze a multi-scale time integrator pseudospectral method for the Dirac equation, and prove its uniform convergence in the non-relativistic limit regime.

Finite-element tools for the simulation of Bose-Einstein condensates

Ionut Danaila

University De Rouen, France

Abstract

We present several numerical tools using classical finite elements with mesh adaptivity for solving different models used for the study of Bose-Einstein condensates. The programs are written as a toolbox for FreeFem++ (www.freefem.org), a free finite-element software, allowing to easily implement various numerical algorithms. For solving the stationary (imaginary-time) Gross-Pitaevskii equation, we use two robust and optimised numerical methods: a steepest descent method based on Sobolev gradients and a minimization algorithm based on the state-of-the-art optimization library IPOPT. A very recent conjugate-gradient method using concepts of Riemannian optimization is also presented. For the Bogoliubov-de Gennes system, representing a linearization of the

Gross-Pitaevskii equation, a Newton method and a fast algorithm based on ARPACK for the calculation of eigenvalues are available. For the real-time Gross-Pitaevskii equation, classical splitting and relaxation methods were implemented and intensively tested. Validations and illustrations are presented for computing difficult configurations with vortices observed in physical experiments: single-line vortex, Abrikosov lattice, giant vortex, dark/anti-dark solitons in one or two-component Bose-Einstein condensates. This is a joint work with F. Hecht, P. Kevrekidis, B. Protas, G. Vergez.

Inhomogeneous Boltzmann-type equations modelling opinion leadership and political segregation

Bertram Duering

University of Sussex, United Kingdom

Abstract

We propose and investigate different kinetic models for opinion formation, when the opinion formation process depends on an additional independent variable, e.g. a leadership or a spatial variable. More specifically, we consider: (i) opinion dynamics under the effect of opinion leadership, where each individual is characterized not only by its opinion, but also by another independent variable which quantifies leadership qualities; (ii) opinion dynamics modelling political segregation in `The Big Sort', a phenomenon that US citizens increasingly prefer to live in neighborhoods with politically like-minded individuals. Based on microscopic opinion consensus dynamics such models lead to inhomogeneous Boltzmann-type equations for the opinion distribution. We derive macroscopic Fokker-Planck-type equations in a quasi-invariant opinion limit and present results of numerical experiments.

A generalized multiscale model reduction technique for heterogeneous problems

Yalchin Efendiev

Texas A&M University, United States

Abstract

In this talk, I will discuss multiscale model reduction techniques for problems in heterogeneous media. I will describe a framework for constructing local (space-time) reduced order models for problems with multiple scales and high contrast. I will focus on a recently proposed method, Generalized Multiscale Finite Element Method that systematically constructs local multiscale finite element basis functions on a coarse grid, which is much larger than the underlying resolved fine grid. The multiscale basis functions take into account the fine-scale information of the resolved solution space via careful choices of local snapshot spaces and local spectral decompositions. I will discuss the issues related to the construction of multiscale basis functions, main ingredients of the method, and a number of applications. These methods are intended for multiscale problems without scale separation and high contrast.

How duality gives long live to solutions and why entropy agrees with it

Klemens Fellner

University of Graz, Austria

Abstract

Systems of nonlinear reaction-diffusion equations are encountered frequently as models in chemistry, physics, populations dynamics and biology. However, due to the lack of comparison principles for general reaction-diffusion systems, already the existence of global weak/classical solutions poses many open problems, in particular in 3D. In the absence of comparison principles, so called Duality Methods have recently proven to be one of the most powerful tools in obtaining global solutions for nonlinear reaction-diffusion systems. The first part of this talk will present recent advances and results concerning the existence of global solutions via duality methods. The second part of the talk will then consider reaction-diffusion systems, which feature an entropy functional and discuss the convergence to equilibrium states with computable rates for large classes of such reaction-diffusion models.

On the existence of Rarefaction Shock Waves

Ingenuin Gasser

Universitat Hamburg, Germany

Abstract

We study the possibility of expansive shock waves in single phase fluids. A crucial quantity related to this issue is the so called fundamental derivative. We proof the existence of expansive shock waves for a general class of fluids if the fundamental derivative at some point (in the $\tau-p$ plane) becomes negative.

Recent progresses in the theory of mean-field games

Diogo Gomes

King Abdullah University of Science & Technology, Saudi Arabia

Abstract

In this talk, we discuss some recent progresses in the theory of mean-field games. First, we examine monotonicity methods and its applications to the existence theory for MFGs and to the construction of numerical methods. Next, we consider non-monotone mean-field games and, through a rather explicit analysis, we uncover new phenomena that are not present in the monotone case. Finally, if time permits, we will examine several one-dimensional problems that are given by hyperbolic conservation laws. Here, we discuss new wave-like equations, conserved quantities and various asymptotic properties.

Bloch decomposition based method for quantum dynamics in periodic media

Zhongyi Huang

Tsinghua University, China

Abstract

In this talk, we will give a short review of our Bloch based method for quantum dynamics in heterogeneous media with periodic microstructures. Furthermore, we will also present some recent results of the applications to some physical problems.

On stabilizing effect of the magnetic field in the magnetic Rayleigh-Taylor problem

Song Jiang

Institute of Applied Physics and Computational Mathematics, China

Abstract

We investigate the stabilizing effect of the vertical equilibrium magnetic field in the Rayleigh-Taylor (RT) problem for a non-homogeneous incompressible/compressible viscous magneto-hydrodynamic (MHD) fluid of zero resistivity in the presence of a uniform gravitational field in a horizontally periodic domain, in which the velocity of the fluid is non-slip on both upper and lower flat boundaries. When an initial perturbation around a magnetic RT equilibrium state satisfies some relations, and the strength of the vertical magnetic field of the equilibrium state is bigger than the critical number, we can use the Bogovskii function in the standing-wave form and adapt a two-tier energy method in Lagrangian coordinates to show the existence of a unique global-in-time (perturbed) stability solution to the magnetic RT problem. For the case that the strength of the vertical magnetic field is smaller than the critical number, by developing new analysis technique based on the method of bootstrap instability, we show that the nonlinear RT instability will occur. The current result reveals from the mathematical point of view that the sufficiently large vertical equilibrium magnetic field has a stabilizing effect and can prevent the RT instability in MHD flows from occurring. Similar conclusions can be also verified for the horizontal magnetic field when the domain is vertically periodic, which shows the horizontal magnetic field has the same stabilizing effect as the vertical one. (joint work with Fei Jiang)

Multidomain spectral method for Schrödinger equations

Christian Klein

Université de Bourgogne, France

Abstract

A multidomain spectral method with compactified exterior domains combined with stable second and fourth order time integrators is presented for Schrödinger equations. The numerical approach allows high precision numerical studies of solutions on the whole real line. At examples for the linear and cubic nonlinear Schrödinger equation, this code is compared to transparent boundary conditions and perfectly matched layers approaches. The code can deal with asymptotically non vanishing solutions as the Peregrine breather being discussed as a model for rogue waves. It is shown that the Peregrine breather can be numerically propagated with essentially machine precision, and that localized perturbations of this solution can be studied. The approach is generalized to two spatial dimensions and explicit time integration schemes.

On a Boltzmann mean field model for knowledge growth

Alexander Lorz

Université Pierre Marie Curie, France

Abstract

In this paper we analyze a Boltzmann type mean field game model for knowledge growth, which was proposed by Lucas and Moll. We discuss the underlying mathematical model, which consists of a coupled system of a Boltzmann type equation for the agent density and a Hamilton-Jacobi-Bellman equation for the optimal strategy. We study the analytic features of each equation separately and show local in time existence and uniqueness for the fully coupled system. Furthermore we focus on the existence of special solutions, which are related to exponential growth in time - so called balanced growth path solutions. This is joint work with Martin Burger and Marie-Therese Wolfram.

Mathematical problems for the Quantum Hydrodynamic Systems in Superfluidity and other applications

Pierangelo Marcati

University of L'Aquila, Italy

Abstract

We study the Landau - Khalatnikov and other two fluid systems modeling the interaction of a classical and a quantum fluid. We can prove the global existence of finite energy weak solutions, by applying some of the methods created by Antonelli and Marcati for the analysis of the single QHD model. In the case of the two fluids it has been necessary to extend the classical results of Fujiwara (based on the Feynman path integration) to the case of potential L^p in time.

References:
[1] P. Antonelli and P. Marcati, On the finite energy weak solutions to a system in Quantum Fluid Dynamics, Comm. Math. Phys. 287 (2009), no 2, 657–686.
[2] P. Antonelli and P. Marcati, The Quantum Hydrodynamics system in two space dimensions, Arch. Rat. Mech. Anal. 203 (2012), 499–527.
[3] P. Antonelli and P. Marcati, Quantum hydrodynamics with nonlinear interactions. Discrete Contin. Dyn. Syst. Ser. S 9 (2016), no. 1, 1–13.
[4] P. Antonelli and P. Marcati, Finite energy global solutions to a two-fluid model arising in superfluidity. Bull. Inst. Math. Acad. Sin. (N.S.) 10 (2015), no. 3, 349–373.
[5] P. Antonelli M.D'Amico and P. Marcati, paper in preparation on the extension of the Fujiwara theorem.

Modelling and computation of a fluid experiment with quantum-like behaviour

Paul A Milewski

University of Bath, United Kingdom

Abstract

Recent experiments by two groups, led by Yves Couder (Paris) and John Bush (MIT) have shown experimentally that droplets will bounce on the surface of a vertically vibrated bath (instead of coalescing with it), generating a weakly damped Faraday wave field at every bounce. As the forcing is increased, a bifurcation leads to a "walking" state whereby the bouncing droplet is guided by the self-generated wave field: the droplet's pilot wave. Once this state is achieved a large array of interesting dynamics ensues with surprising analogies to quantum mechanical behaviour, in particular to DeBroglie's pilot wave theory. We present a coupled particle-fluid model that can be used to simulate the dynamics of this problem, together with the verification of some of its quantum mechanical-like behaviour.

Numerical techniques for mean-field equations of collective behavior with uncertainties

Lorenzo Pareschi

University of Ferrara, Italy

Abstract

In this talk we survey some recent results on the construction of numerical methods for mean-field equations describing collective behaviours. An essential step in the study of such models is represented by the introduction of stochastic parameters reflecting the uncertainty in the terms defining the interaction rules. This is particularly relevant in emerging fields like social sciences and economy where the interaction rules are based on observations and empirical evidence. In such cases uncertainty exists in most modelling parameters. Here we discuss the construction of numerical schemes which are capable to preserve some relevant properties, like steady states and non negativity of the solution. we will consider both collocation and Galerkin approaches for the random variables.

PDE models of natural networks

Benoit Perthame

Université Pierre Marie Curie, France

Abstract

Transportation networks have been widely produced by nature. Neural networks, leaf vena-tures, vascular system, roots are example which share the property that the network transports auid or a current. In some cases, the formation of the network, during development of the individual, is based on a prematrix which can be seen has a porous media. The pressure produced by a source acts on this prematrix and generates new vessels. Physicists have proposed PDE models for to describe this interaction under the form of a singular system of parabolic/elliptic type.
This lecture will present some mathematical features of this system: energy considerations and existence of solutions, multiple and singular steady states.
This work is a collaboration with J. Haskovec, P. Markowich and M. Schlottbom.

A plane wave virtual element method for the Helmholtz problem

Paola Pietra

Consiglio Nazionale delle Ricerche at Pavia, Italy

Abstract

The virtual element method (VEM) is a generalization of the finite element method recently introduced, which takes inspiration from mimetic finite difference schemes, and allows to use very general polygonal/polyhedral meshes. Because of the oscillatory behavior of solutions to the Helmholtz equation, methods that incorporate information about the solution in the form of plane waves have received attention in the last years. The new method presented here is based on inserting plane wave basis functions within the VEM framework aiming at constructing an H_1 - conforming, high-order method for the discretization of the Helmholtz problem. The main ingredients of this plane wave-VEM (PW-VEM) are: i) a low frequency space made of VEM functions, whose basis functions are not explicitly computed in the element interiors; ii) a proper local projection operator onto the high-

frequency space, made of plane waves; iii) an approximate stabilization term. Convergence of the h-version of the PW-VEM is given and numerical results testing its performance on general polygonal meshes are presented.

Customising image Analysis Using Nonlinear Partial Differential Equations

Carola Schoenlieb

University of Cambridge, United Kingdom

Abstract

We humans are visual creatures. We live in a world saturated with images and images allows us to see this world - from brain cells to distant galaxies - as never before. This wealth of images and the information they carry is overwhelming in its size and complexity. Automated image analysis methods are required to process them, find patterns and extract meaningful information. When assigned with the task of extracting information from given image data the first challenge one faces is the derivation of a truthful model for both the information and the data. Such a model can be determined by the a-priori knowledge about the image (information), the data and their relation to each other. The source of this knowledge is either our understanding of the type of images we want to reconstruct and of the physics behind the acquisition of the data or we can thrive to learn parametric models from the data itself. The common question arises: how can we customize our model choice to a particular application? Or better how can we make our model adaptive to the given data?

Starting from the first modelling strategy this talk will lead us from nonlinear diffusion equations and subdifferential inclusions of total variation type functionals as the most successful image model today to non-smooth second- and third-order variational models, with data models for Gaussian and Poisson distributed data as well as impulse noise. These models exhibit solution-dependent adaptivities in form of nonlinearities or non-smooth terms in the PDE or the variational problem, respectively. Applications for image denoising, inpainting and surface reconstruction are given. After a critical discussion of these different image and data models we will turn towards the second modelling strategy and propose

to combine it with the first one using a PDE constrained optimisation method that customizes a parametrized form of the model by learning from examples. In particular, we will consider optimal parameter derivation for total variation denoising with multiple noise distributions and optimizing total generalized variation regularization for its application in photography.

The Filament Based Lamellipodium Model (FBLM)

Christian Schmeiser

University of Vienna, Austria

Abstract

The lamellipodium is a flat cell protrusion, serving as the motility organelle of cells spreading on flat substrates. The shape and the movement of the lamellipodium are determined by the dynamics of an approximately two-dimensional network of polymer filaments. This system is influenced by the nucleation and deactivation of filaments, by their polymerization and depolymerization, by their resistance against bending, by dynamic cross-linking and adhesion to the substrate, by the interaction with the enclosing cell membrane, by the action of motor proteins, and by signalling networks regulating some of these effects. The FBLM is a two-dimensional, two-phase, anisotropic continuum model, taking into account most of these ingredients. Several ingredients of the model and a number of simulation results will be presented. (joint work with A. Manhart, D. Oelz, N. Sfakianakis)

Regularity of solutions to “Broken” PDEs

Henrik Shagholian

Kungliga Tekniska högskolan, Sweden

Abstract

I shall discuss recent developments of PDEs where there is a qualitative change of the equation across a level set. Central themes of the discussion

concern regularity of solutions as well as that of the level set, where PDE breaks.

Efficient spectral methods for solving a class of fractional PDEs in unbounded domains

Jie Shen

Purdue University, United States and Xiamen University, China

Abstract

We construct efficient spectral approximations of fractional diffusion equations in the unbounded domains. We will present rigorous error estimates, and ample numerical examples, including in particular fractional nonlinear Schrodinger equations, to show the effectiveness of our approach.

Scalar conservation laws with rough time dependence

Takis Souganidis

University of Chicago, United States

Abstract

I will present a recently developed theory for scalar conservation laws with nonlinear multiplicative rough signal dependence. I will describe the difficulties, introduce the notion of pathwise entropy/kinetic solution and its well-posedness. I will also talk about the long time behavior of the solutions as well as some regularization by noise type results.

Efficient and accurate numerical methods for computing the ground states and dynamics of spin 2 Bose-Einstein condensates

Qinglin Tang

Universite de Lorraine, France

Abstract

In this talk, we will propose some efficient numerical methods for computing the ground states and dynamics of the spin-2 Bose-Einstein condensates (BECs) modeled by the Gross-Pitaevskii equations (GPEs). For the ground states computation, we will extend the celebrated normalized gradient flow (NGF) or imaginary time method (ITM) to the spin-2 case. The main merit is to find the five projection or normalization conditions that are used in the projection step of NGF/ITM. Based on the relations between chemical potentials and the two physical constraints given by the conservation of the total mass and magnetization, these five projection or normalization conditions can be completely and uniquely determined. As for the dynamics simulation, a compact time-splitting scheme will be proposed. The method simply solve the GPEs in two steps, which is very easy to be extended to higher time marching schemes. Extensive interesting numerical results will also be reported.

Continuous data assimilation for the three-dimensional Brinkman-Forchheimer-extended Darcy Model

Saber Trabelsi

King Abdullah University of Science & Technology, Saudi Arabia

Abstract

In this talk, I will introduce the three-dimensional Brinkman-Forchheimer-extended Darcy Model of Porous media. This model is believed to be accurate when the flow velocity is too large for Darcy's law to be valid, and additionally the porosity is not too small. Next, I will introduce a continuous data assimilation algorithm for this model. The algorithm is inspired by ideas developed for designing finite-parameters feedback control for dissipative systems. It aims to obtain improved

estimates of the state of the physical system by incorporating deterministic (or noisy) measurements and observations. Specifically, the algorithm involves a feedback control that nudges the large scales of the approximate solution toward those of the reference solution associated with the spatial measurements. Eventually, I will show the convergence of the algorithm' solutions to the reference solutions (solution of the original mathematical system). Work jointly with Peter A. Markowich and E. S. Titi.

The relative entropy method; connection with the second law and variational structures

Athanasis Tzavaras

King Abdullah University of Science & Technology, Saudi Arabia

Abstract

The relative entropy method is a calculation developed for hyperbolic conservation laws by Dafermos and DiPerna, which exploits the thermodynamical entropy structure of hyperbolic systems in order to compare two appropriate solutions of the same or related thermo mechanical systems. In this talk I will survey extensions of such calculations in two directions :

(a) for entropy dissipating hyperbolic-parabolic systems where the hyperbolic part is symmetrizable. This indicates the role of the second law of thermodynamics and as an application provides convergence from the system of thermo visco-elasticity to the system of adiabatic elasticity in the limit as the viscosity and heat conduction tend to zero for smooth solutions.

(b) Euler flows generated by a variational structure induced by an energy functional. The latter class admits as examples the Euler-Korteweg system and the Euler-Poisson system and yields various asymptotic convergence results again for smooth solutions.
The talk is based on joint works with C. Christoforou (Univ. of Cyprus), J. Giesselmann (Univ. of Stuttgart) and C. Lattanzio (Univ. dell'Aquila).

Energy stable numerical methods for dissipative partial differential equation systems

Qi Wang

Beijing Computational Science Research Center, China

Abstract

Dissipative partial differential equations for fluid flows of various types share a common mathematical structure derived from the generalized Onsager principle and variational principle. The combination of these two principles allows one to develop a general framework to design numerical algorithms for the dissipative partial differential equations. In this talk, I will discuss some recent development in energy stable numerical algorithms for various multiphase and complex fluid flow models.

Price formation: from Boltzmann to mean field models

Marie-Therese Wolfram

Radon Institute for Computational and Applied Mathematics, Austria

Abstract

In 2007 Lasry & Lions introduced a simple mean field model for the dynamical formation of a price. The model consists of a system of parabolic equations for the trader densities with the agreed price entering as a free boundary. In this talk we present two price formation models, which were motivated by the work of Lasry and Lions. The first model is a simple agent based trade model with standard stochastic price fluctuations and discrete trading events. By modeling trading events between vendors and buyers as kinetic collisions one can prove rigorously that in the limit of large trading frequencies, the proposed Boltzmann model converges to the Lasry and Lions mean field model. Second we present a generalization of the Lasry & Lions model, which includes fluctuations in the number of buyers and vendors. We analyse the model in the case of deterministic and stochastic market size fluctuations and present results on the long time asymptotic behavior.

Joint work with M. Burger (WWU Münster), L. Caffarelli (Texas), P.A. Markowich (Vienna and Kaust) and J. Teichmann (ETH Zürich)

Nonlinear asymptotic stability of the Lane-Emden solution for the viscous gaseous star problem

Zhouping Xin

Chinese University of Hong Kong, China

Abstract

In this talk, I will present some recent works on the nonlinear asymptotic stability of the Lane-Emden Solutions for the Navier-Stokes-Poisson systems with positive or degenerate viscosities. This is one of the challenging problems in the theory of viscous star problems. Some of the key ideas and analysis will be discussed. These are joint works with Tao Luo and Huihui Zeng.

Measure Valued Solutions to the Boltzmann Equation

Tong Yang

City University of Hong Kong, China

Abstract

In this talk, we will present some recent results on the well-posedness, regularity and large time behavior of the measure valued solutions. The results are from several joint works with Yong-Kum Cho,Yoshinori Morimoto, Shuaikun Wang and Huijiang Zhao.

Existence and Stability of the Stationary Solution to the Compressible Navier-Stokes-Poisson Equations in a Half Line

Kaijun Zhang

Northeastern Normal University, China

Abstract

In this paper, we investigate the asymptotic stability of the stationary solution to outflow problem for the compressible Navier-Stokes-Poisson system in a half line. We show the existence of the stationary solution with the aid of the stable manifold theory. The time asymptotic stability of the stationary solution is obtained by the elementary energy method. Furthermore, for the supersonic flow at spatial infinity, we also obtain an algebraic and an exponential decay rate, when the initial perturbation belongs to the corresponding weighted Sobolev space. The proof is based on a time and space weighted energy method.

Global regularities of two-dimensional density patch for inhomogeneous incompressible viscous flow with general density

Ping Zhang

Chinese Academy of Sciences, China

Abstract

Toward the open question proposed by P.-L. Lions in the book ["Mathematical topics in fluid mechanics", Oxford University Press, 1996] concerning the propagation of regularities of density patch for viscous inhomogeneous flow, we first establish the global in time well-posedness of two-dimensional inhomogeneous incompressible Navier-Stokes system with initial density being of the form: $\eta_1 1_{\Omega_0} + \eta_2 1_{\Omega_0^c}$, for any pair of positive constants (η_1, η_2), and for any $W^{k+2,p}(\mathrm{R}^2)$ domain Ω_0. We then prove that the time evolved domain $\Omega(t)$ also belongs to the class of $W^{k+2,p}$ for any $t>0$. Thus in some sense, we have solved the aforementioned Lions' question of density patch in the two-dimensional case. Compared with our previous paper Liao and Zhang (ARMA, 2016), here we remove the smallness condition on the jump, $|\eta_1 - \eta_2|$, and moreover, the techniques used in the present paper are completely different from those in Liao and Zhang (ARMA, 2016).

Extended WKB analysis for high frequency wave equations

Chunxiong Zheng

Tsinghua University, China

Abstract

The classical WKB analysis is an important tool for seeking the asymptotic solution for high frequency wave equations. However, generally it is not ensured to be valid due to the existence of caustics. In this talk, we proposed an extended version of the WKB method. The basic idea will be explained and some applications will be reported.

A Non-intrusive Stratified Resampler for Regression Monte Carlo

Jorge Zubelli

Instituto Nacional de Matemática Pura Aplicada, Brazil

Abstract

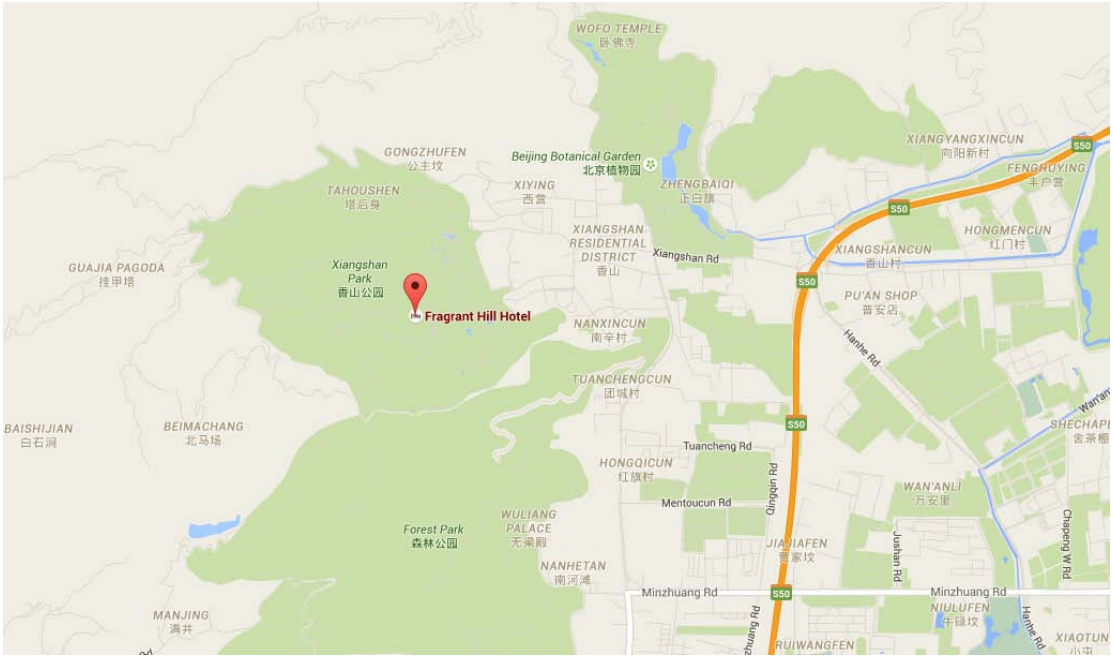
Stochastic dynamic programming equations are classic equations arising in the resolution of nonlinear evolution equations, like in stochastic control. In this talk we address a technique to solve certain dynamic programming equations associated to a given Markov chain X, using a regression-based Monte Carlo algorithm. More specifically, we assume that the model for X is not known in full detail and only a root sample $X^1,\ldots,X^M$ of such process is available. By a stratification of the space and a suitable choice of a probability measure, we design a new resampling scheme that allows to compute local regressions (on basis functions) in each stratum. The combination of the stratification and the resampling allows to compute the solution to the dynamic programming equation (possibly in large dimension) using only a relatively small set of root paths. To assess the accuracy of the algorithm, we establish non-asymptotic error estimates in L^2 of the chosen measure. Our numerical experiments illustrate the good performance, even with as low as 20s to 40 root paths. This is joint work with Emmanuel Gobet and Gang Liu (E. Polytechnique, Paris).

List of Participants

Address note 1: Fragrant Hill Hotel

To the taxi driver:
师傅，您好，请把我送到香山饭店，并提供发票，谢谢！地址是：北京市海淀区买卖街 40 号（香山公园内）。

Please take me to Fragrant Hill Hotel, the address is shown in the map below. Thanks.

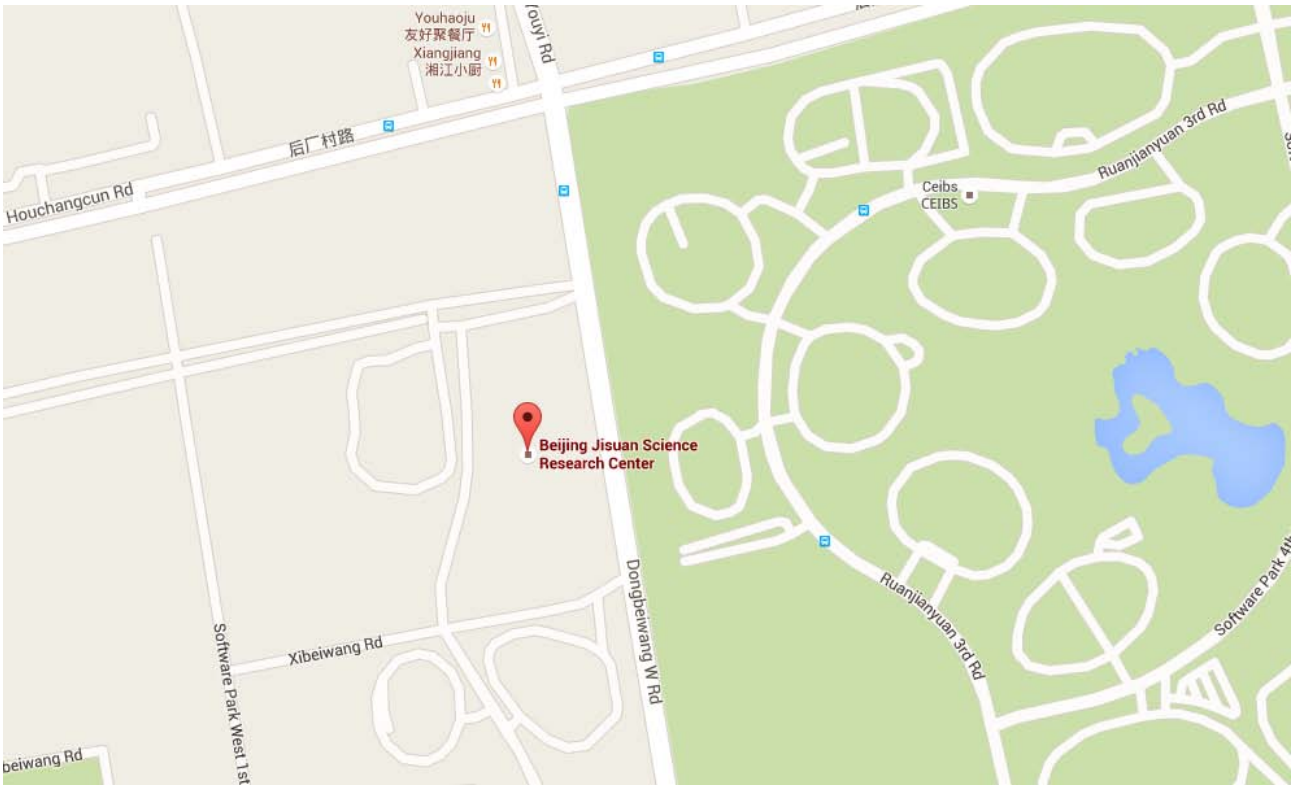


Address note 2:
Beijing Computation Science Research Center （CSRC）

To the taxi driver:

师傅，您好，请把我送到北京计算科学研究中心，并提供发票，谢谢！地址是：北京市海淀区西北望东路 10 号院东区 9 号楼，中关村软件园二期。

Please take me to CSRC, the address is shown in the map below. Thanks



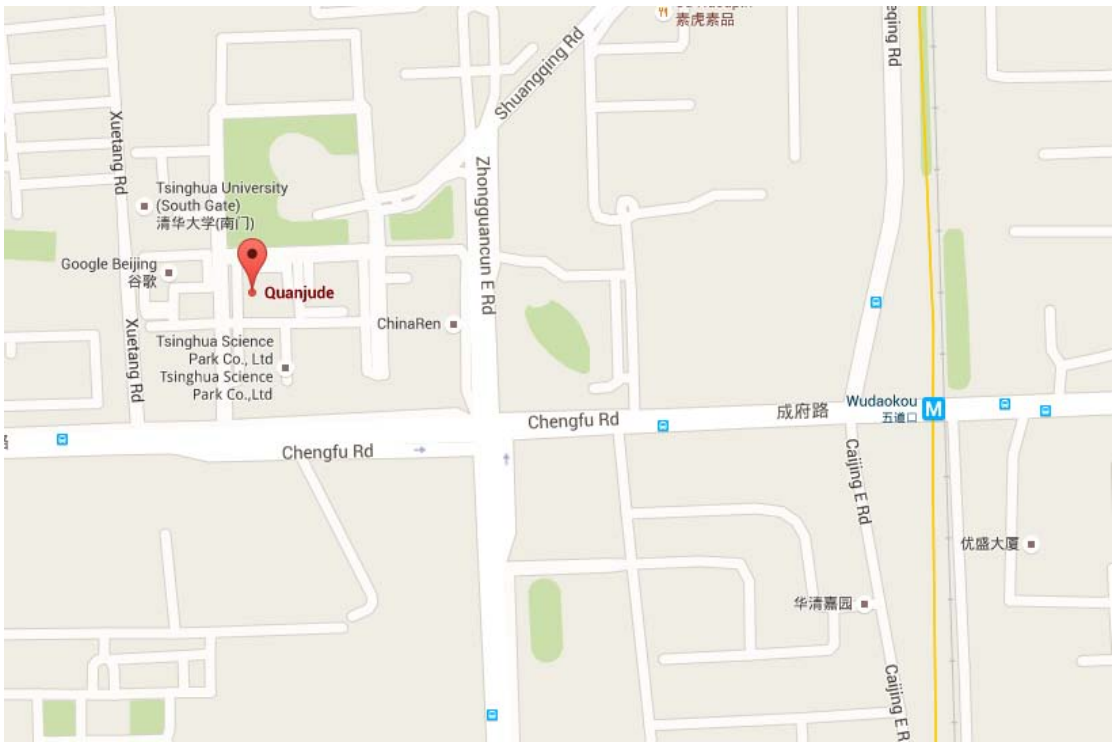
Address note 3:
QuanJuDe（Banquet Restaurant）

To the taxi driver:

师傅，您好，请把我送到全聚德清华园店，并提供发票，谢谢！地址是：北京市中关村东路 1 号院清华科技园科技大厦 A 座一层

Please take me to Qujude Restaurant, the address is shown in the map below. Thanks.

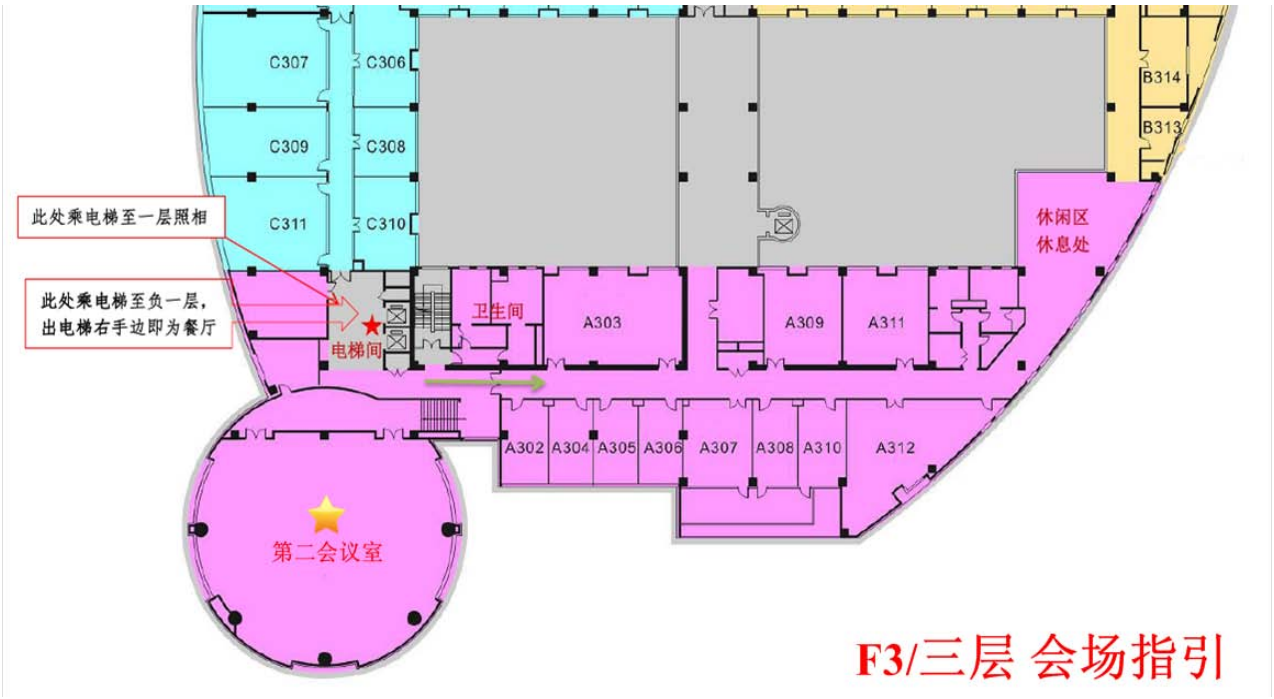
Note: You can also take a walk to the restaurant from the Metro Station Wudaokou (Wudaokou is known as "the center of the universe" in Beijing), as shown in the map.



Useful Information to Beijing CSRC

For your convenience, here are ***Some Important Tips***:

1. CSRC Address:
   - ✧ Building 9, East Zone, ZPark II, No.10 Xibeiwang East Road, Haidian District, Beijing 100094, China
   - ✧ 北京市海淀区西北旺东路 10 号院东区 9 号楼 Onsite Registration:
   - ✧ Time: 9:30~17:30 (July 6, Wednesday)
2. Venue: Conference Room II, 3rd Floor (中心三层第二会议室)
3. Lunch & Dinner Place: Canteen, B1 Floor (中心地下一层餐厅)
4. Free Wi-Fi: csrc_guest, password: csrc20150308



<u>Recommended Route</u>

Taxi:

1) From Capital International Airport (首都国际机场): The cost is about 130 RMB (50mins).

2) From Beijing Railway Station (北京站): The cost is about 100 RMB (80 mins).

3) From Beijing West Railway Station (北京西站): The cost is about 70 RMB (60mins).

4) From Beijing South Railway Station (北京南站): The cost is about 105 RMB (90mins).

5) From Beijing North Railway Station(北京北站): The cost is about 60 RMB (45mins)

Local Bus:

Bus #205 (Software Park West Stop/软件园西区站)

Bus #333 (Houchangcun East Stop/后厂村东站)

Bus #963/#982 (Dongbeiwang West Road North Stop/东北旺西路北口站)

Subway:

Take Subway Line 13 to "SHANG DI Station(上地站)", take Exit A to catch Bus #205 to "Software Park West Stop(软件园西区站)". Enter the park and proceed toward in the north direction, CSRC will be to your right in 400 meters.