华南数学应用与交叉研究中心
South China Research Center for Applied Mathematics and Interdisciplinary Studies

CAMIS-SCNU
Conference

流体和固体中的界面问题国际会议

International Conference on Interface Problem in Fluid and Solid

Brochure

会议手册

South China Research Center for Applied Mathematics
and Interdisciplinary Studies (CAMIS), South China Normal University
华南师范大学华南数学应用与交叉研究中心

Guangzhou, China
June 18-21, 2019

Address: Zhong Shan Avenue West 55, Tianhe District, Guangzhou 510631, China
地址：广东省广州市天河区中山大道西55号　　邮编：510631
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1. Useful Information

(1) Timetable

International Conference on Interface Problem in Fluid and Solid June 18-21, 2019				
Time	**June 18th (Tuesday)**	**June 19th (Wednesday)**	**June 20th (Thursday)**	**June 21st (Friday)**
8:30-9:15	**8:30--9:05 Registration** **9:05 –9:15 Opening remarks**	**David Srolovitz**	**Sijue Wu**	**Christian Ratsch**
9:15-10:00	**Fanghua Lin**	**Lei Xu**	**Xianming Xu**	**Richard Tasi**
10:00-10:30	Coffee break	Coffee break & Photos	Coffee break	Coffee break
10:30-11:15	**Tim Laux**	**Tiezhen Qian**	**Juncheng Wei**	**Yang Xiang**
11:15-12:00	**Qiang Du**	**Wenjun Ying**	**Kazifumi Ito**	**Weicheng Wang**
12:00-14:00	Lunch	Lunch	Lunch	Closing Remarks &.Lunch
14:00-14:45	**Qi Wang**	**Xiaochuan Tian**	**Eugene Rabkin**	**Departure**
14:45-15:30	**Suchuan Dong**	**Xiaofan Li**	**Dong Wang**	
15:30-16:00	Coffee break	Coffee break	Coffee break	
16:00-16:45	**Zhilin Li**	**Jie Shen**	**Tao Lin**	
16:45-17:30	**Zhenli Xu**	**Weiqing Ren**	**Poster Session**	
17:30-20:00	Dinner	Banquet	Dinner	

(2) Address

①**Accommodation:** Huashi Hotel (华师大厦酒店)

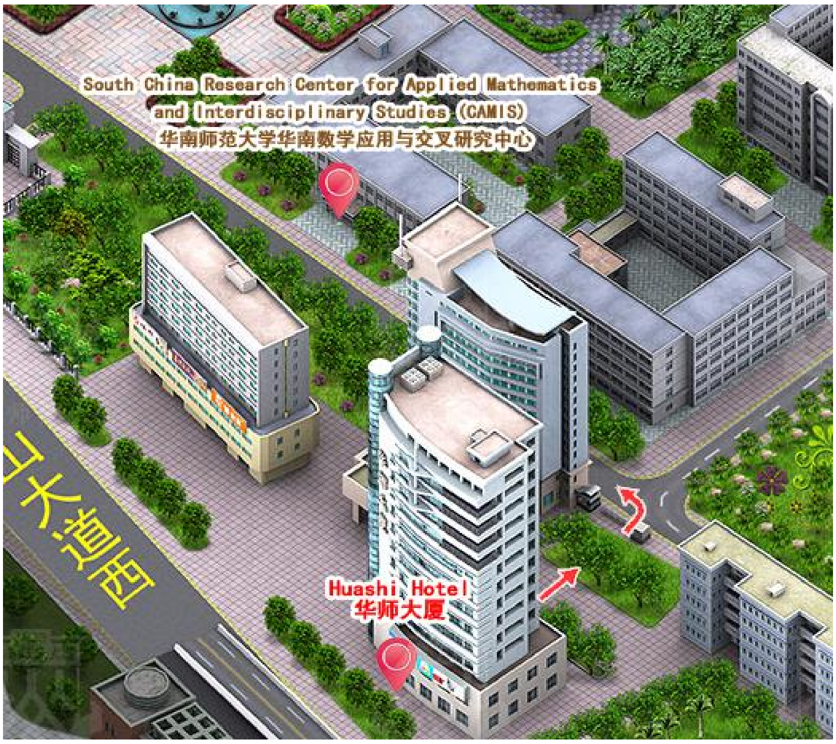
②**Hotel Address:** Zhongshan Avenue West No. 69, Tianhe District, Guangzhou 510631, China

(广州市中山大道西 69 号华师大厦酒店（原华师粤海酒店））

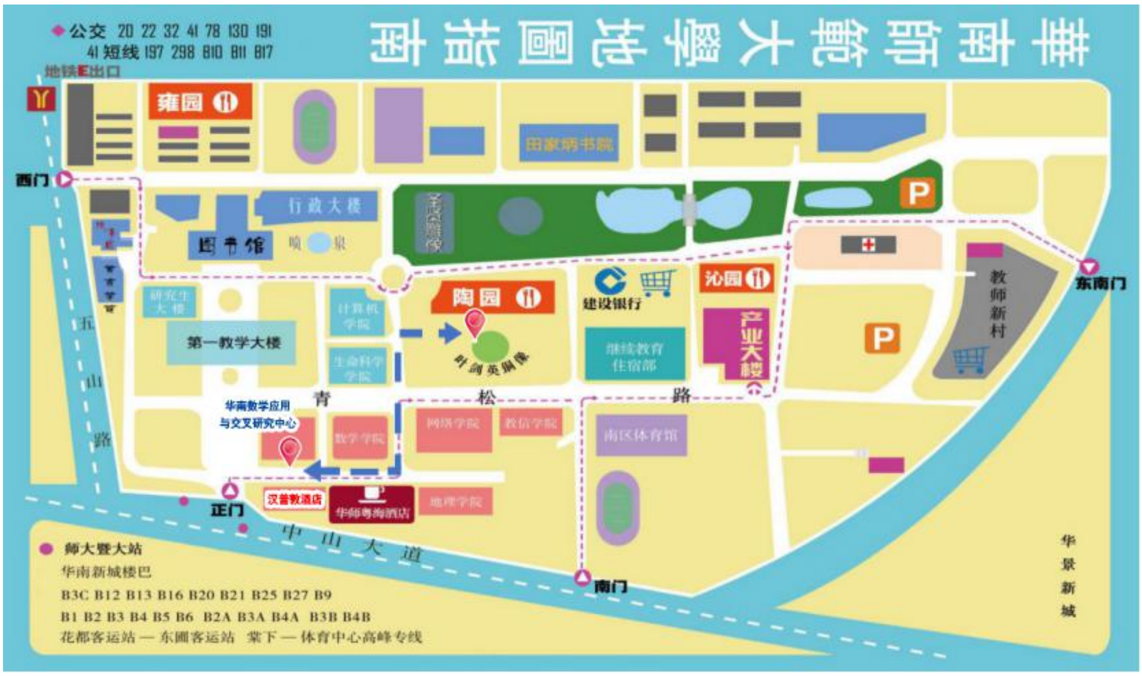
③**Talk venue:** South China Research Center for Applied Mathematics and Interdisciplinary Studies (CAMIS),

South China Normal University （华南师范大学华南数学应用与交叉研究中心）

(3) Map: Huashi Hotel-- CAMIS



(4) Map: CAMIS-- Taoyuan



2.Programme

Date	Time	Activity	Venue
June 17th Mon.	9:00-18:00	Registration	**The hall of CAMIS**
	11:30-13:30	Lunch	**Huashi Hotel Buffet**
	18:00-20:30	Dinner	**Huashi Hotel Buffet**
June 18th Tues.	08:30-09:05	Registration	**Room 111 of CAMIS**
	09:05-09:15	Opening remark by **Prof. Zhouping XIN**	
	Session 1. Chairman: **Prof. Zhouping XIN**		
	09:15-10:00	*Liquid Crystal Droplet and Its Orientation Configuration* **Prof. Fanghua LIN**	
	10:00-10:30	Coffee break	
	Session 2. Chairman: **Prof. Xiaoping WANG**		
	10:30-11:15	*Weak-strong uniqueness for multiphase mean curvature flow* **Prof.Tim Laux**	
	11:15-12:00	*Nonlocal gradient operators in peridynamics and SPH* **Prof. Qiang DU**	
	12:00-14:00	Lunch	**Huashi Hotel**
	Session 3. Chairman:**Prof.Zhilin LI**		
	14:00-14:45	*Thermodynamically consistent modeling and simulation for interfacial dynamics using phase field models* **Prof. Qi WANG**	
	14:45-15:30	*Multiphase Flows of N (N>=2) Immiscible Incompressible Fluids: Modeling and Algorithms* **Prof. Suchuan DONG**	
	15:30-16:00	Coffee break	
	Session 4. Chairman: **Prof.Qi WANG**		
	16:00-16:45	*Some progress on Maxwell & anisotropic interface problems* **Prof.Zhilin LI**	
	16:45-17:30	*Mathematical model for charge transport in nanofluidic problems* **Prof.Zhenli XU**	
	17:30	Dinner	**Taoyuan restaurant**

June 19th Wed.	Session 1. Chairman: **Prof.Weizhu BAO**		
	08:30-9:15	*Evolution of Microstructure in Polycrystalline Materials* **Prof. David Srolovitz**	
	09:15-10:00	*Diffusion-dominated pinch-off of ultralow surface tension fluids* **Prof. Lei XU**	
	10:00-10:30	Coffee break &.Photos	
	Session 2. Chairman: **Prof.David Srolovitz**		
	10:30-11:15	*Onsager's variational principle and its applications to interfacial dynamics in fluid and solid* **Prof.Tiezhen QIAN**	
	11:15-12:00	*Analysis on the potential theory based Cartesian grid method for interface problems* **Prof.Wenjun YING**	
	12:00-14:00	Lunch	**Huashi Hotel**
	Session 3. Chairman: **Prof.Jie SHEN**		
	14:00-14:45	**Prof.Xiaochuan TIAN**	
	14:45-15:30	*Motion of particles in unsteady Stokes and linear viscoelastic fluids* **Prof. Xiaofan LI**	
	15:30-16:00	Coffee break	
	Session 4. Chairman:**Prof.Qiang DU**		
	16:00-16:45	*Structure preserving schemes for complex nonlinear systems* **Prof. Jie SHEN**	
	16:45-17:30	*Interface Profile Near the Contact Line in Electro-wetting on Dielectric* **Prof. Weiqing REN**	
	17:30	Banquet	**Taoyuan restaurant**
June 20th Thurs.	Session 1. Chairman: **Prof.Fanghua LIN**		
	08:30-9:15	*On the motion of water waves with angled crests* **Prof. Sijue WU**	
	09:15-10:00	*Modeling and Analysis for contact angle hysteresis on rough surfaces* **Prof. Xianming XU**	
	10:00-10:30	Coffee break	

	Session 2. Chairman: **Prof.Shijin DING**		
	10:30-11:15	*Finite time singularity of the nematic liquid crystal flow in dimension two* **Prof. Juncheng WEI**	
	11:15-12:00	*Optimal control of PDEs with pointwise state constraint* **Prof. Kazifumi Ito**	
	12:00-14:00	Lunch	**Huashi Hotel**
	Session 3. Chairman:**Prof. Yang XIANG**		
	14:00-14:45	*Kangaroo-type Ni-Cr2O3 nanoparticles obtained by solid state dewetting of Ni-Cr multilayers* **Prof. Eugene Rabkin**	
	14:45-15:30	**Prof.Dong WANG**	
	15:30-16:00	Coffee break	
	Session 4. Chairman: **Prof.Xiaofan LI**		
	16:00-16:45	*Some Applications of Immersed Finite Element Methods* **Prof.Tao LIN**	
	16:45-17:30	**Poster Session**	
	17:30	Dinner	**Taoyuan restaurant**
June 21th Fri.	Session 1. Chairman:**Prof. Jinkai LI**		
	08:30-9:15	*Mound Formation during Epitaxial Growth studied by Kinetic Monte Carlo and Island Dynamics Simulations* **Prof.Christian Ratsch**	
	09:15-10:00	*Implicit boundary integral methods and applications* **Prof.Richard Tasi**	
	10:00-10:30	Coffee break	
	Session 2. Chairman:**Prof.Christian Ratsch**		
	10:30-11:15	*Energy and Dynamics of Grain Boundaries Based on Underlying Mircrostructure* **Prof. Yang XIANG**	
	11:15-12:00	*An efficient solver for the coupled Darcy-Stokes system* **Prof.Weicheng WANG**	
	12:00-14:00	Closing Remarks &.Lunch	**Huashi Hotel**

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Xiaoping Wan(王筱平)	Hong Kong University of Science and Technology &. CAMIS
Weizhu Bao(包维柱)	National University of Singapore &. CAMIS
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3.Abstract &. Title

Multiphase Flows of N (N>=2) Immiscible Incompressible Fluids: Modeling and Algorithms

Suchuan Dong(董素川) (Purdue University)

This talk concerns the modeling and simulation of isothermal multiphase flows consisting of N (N>=2) immiscible incompressible fluids with different physical properties (e.g. densities, viscosities, and pair-wise surface tensions). These problems are characterized by multiple types of fluid interfaces and associated surface tensions, multiple three-phase lines, density contrasts and viscosity contrasts, and multiple types of contact lines and contact angles when solid walls are present.We explore the implications of physical consistencies, in particular reduction consistency and thermodynamic consistency, on the modeling and formulation of such systems. By reduction consistency we refer to the property that if only a set of M (1<=M<=N-1) fluids are present in the system (while the other fluid components are absent) then the N-phase governing equations and boundary conditions will exactly reduce to those for the corresponding M-phase system. By thermodynamic consistency we refer to the property that the formulation honors the thermodynamic principles and rigorously satisfies the mass conservation, momentum conservation, second law of thermodynamics, and the Galilean invariance principle. We present a reduction-consistent and thermodynamically consistent formulation and an efficient numerical algorithm for simulating such problems. Numerical simulations and comparisons with physical theories will be presented to demonstrate the physical accuracies of the presented methods.

Nonlocal gradient operators in peridynamics and SPH

Qiang Du(杜强) (Columbia University)

Nonlocality has become increasingly noticeable in nature. The interest in the effective modeling of its presence motivates new mathematical studies of nonlocal operators. Nonlocal gradients are basic elements of the nonlocal vector calculus that play important roles in nonlocal modeling, analysis and computation. In this talk, we present their basic properties and discuss their applications. As illustrations, we show how they can help design stable nonlocal models of mechanics such as peridynamics for elasticity and fracture mechanics. We also discuss how they can improve the nonlocal relaxation of fluid mechanics models to get more robust numerical scheme in the spirit of smoothed particle hydrodynamics (SPH).

Optimal control of PDEs with pointwise state constraint

Kazufumi Ito (North Carolina State University)

In this talk we discuss a point-wise state constraint problem for a general class of optimal control problems. We use the penalty formulation and derive the necessary optimality condition based on the Lagrange multiplier theory.The existence of Lagrange multiplier associated with the point-wise state constraint as a measure is established. Also we develop a semi-smooth Newton method for the penalty formulation.Numerical tests are presented for parabolic, elliptic and wave equation control problems. The results show that the state constraint optimal control method enables us to develop a much powerful and useful control law.

Weak-strong uniqueness for multiphase mean curvature flow

Tim Laux (University of California, Berkeley)

Multiphase mean curvature flow has, due to its importance in materials science,received a lot of attention over the last decades. On the one hand, there is substantial recent progress in the construction of weak solutions. On the other hand, strongsolutions are—in particular in the case of planar networks—very well understood.In this talk, I will present a weak-strong uniqueness principle: as long as a strong solution to multiphase mean curvature flow exists, any distributional solution with optimal energy dissipation rate has to coincide with this solution.In our proof we construct a suitable relative entropy functional, which in this geometric context may be viewed as a time-dependent variant of calibrations. Just like the existence of a calibration guarantees that one has found a global minimum, the existence of a "time-dependent calibration" ensures that the route of steepest descent in the energy landscape is unique and stable.This is joint work with Julian Fischer, Sebastian Hensel, and Thilo Simon.

Motion of particles in unsteady Stokes and linear viscoelastic fluids

Xiaofan Li(李晓璠) (Illinois Institute of Technology)

Studying effects of moving particles on fluids is of fundamental importance for understanding particle dynamics and binding kinetics. Conventional asymptotic solutions may lead to poor accuracy for neighboring particles. We present an accurate boundary integral method to calculate forces exerted on particles for a given velocity field. The idea is to exploit a correspondence principle between the unsteady Stokes and linear viscoelasticity in the Fourier domain such that a unifying boundary integral formulation can be established for the resulting Brinkman equation.

Some progress on Maxwell & anisotropic interface problems

Zhilin Li(李治林) (North Carolina State University)

In this talk, I will discuss some progress made during my visit to CAMIS. The first topic is an augmented method to solve Maxwell equations using Yee's scheme on a staggered grid with discontinuous media. The finite difference scheme remains the same. Only correction terms are added at grid points near or at the interface. The second topic is a finite element and finite difference method for anisotropic elliptic interface problems. We propose to combine a finite element discretization at regular grid points whose coefficient part matrix is an SPD, while at irregular grid points, a finite difference discretization based on the maximum principle preserving method whose coefficient part matrix is an M-matrix. A multigrid method based a nine-point stencil is employed to solve the linear system of equations. A scaling strategy along the interface is proposed along with the discretization. Error analysis and numerical examples will also be presented.

Liquid Crystal Droplet and Its Orientation Configuration

Fanghua Lin(林芳华) (Courant Institute of Mathematical Sciences)

Liquid crystal droplets are of great interest from physics and applications. They are important in the study of the topological defects (both in a bulk and on a surface of a droplet). Rigorous mathematical analysis are challenging; and there remains many open questions. In this lecture I shall describe some ongoing work concerning liquid crystal droplets and the associated orientation configurations in the classical Oseen-Frank model.

Some Applications of Immersed Finite Element Methods

Tao Lin (Virginia Tech)

Interface problems appear in numerical simulations over domains consisting of multiple materials that result in discontinuous coefficients in the involved partial differential equations whose solutions are often lack of regularity across the material interfaces. This deficiency of the global regularity requires traditional finite element (FE) methods to use fitted meshes in which each element essentially contains one of the materials; otherwise, their performance cannot be guaranteed. Fitted meshes are unstructured unless material interfaces have trivial geometries. Having to use unstructured meshes can negatively impact the efficiency of FE methods in some applications. The recently developed immersed finite element (IFE) methods are non-traditional FE methods that can utilize interface-independent meshes; hence, they can use structured/Cartesian meshes even for interfaces with non-trivial geometries. We present two applications to demonstration the benefits of IFE methods for moving interface problems. The first application is for incompressible interfacial flows governed by the Stokes equation whose interface is driven by the local fluid velocity. The second application is for some interface inverse problems of elliptic partial differential equations in which the approximate interface is driven by the shape optimization algorithm.

Onsager's variational principle and its applications to interfacial dynamics in fluid and solid

Tiezheng Qian(钱铁铮) (Hong Kong University of Science and Technology)

In this talk, I will first give a brief review of Onsager's variational principle, which is of fundamental importance to linear irreversible thermodynamics.I will then present a few applications of this principle to the interfacial dynamics problems in fluid and solid, including (1) thin film hydrodynamics of binary mixtures, (2) the coffee ring effect, and (3) solid-state dewetting.

Kangaroo-type Ni-Cr2O3 nanoparticles obtained by solid state dewetting of Ni-Cr multilayers

Eugene Rabkin (Israel Institute of Technology)

We employed the solid state dewetting method to produce nanoparticles from the Ni-Cr multilayers deposited on sapphire substrate. During annealing chromium oxidized and migrated towards the metal-sapphire interface. At the late stages of dewetting small nanoparticles of Cr2O3 at the metal-sapphire interface were partially embedded in the larger Ni particles, with the latter forming an overhang, so that the whole particle resembled an adult kangaroo (Ni) with a baby in a pouch (Cr2O3). We have built a kinetic model of simultaneous shape evolution of the two-phase faceted nanoparticle on substrate illustrating the development of this counter-intuitive morphology. Our model allowed estimating the energy of the Cr2O3-sapphire interface.

Mound Formation during Epitaxial Growth studied by Kinetic Monte Carlo and Island Dynamics Simulations

Christian Ratsch (University of California, Los Angeles)

We have studied the formation of mounds during epitaxial growth using kinetic Monte Carlo (KMC) simulations as well as Island Dynamics simulations that employ the level set method. We will explain the ideas behind the Island Dynamics model and some details of its numerical implementation. In the presence of a step edge barrier (that induces an uphill current) mounds form during epitaxial growth. The slopes of these mounds are stabilized by a downward transport mechanism. We study two different downward transport mechanisms, referred to as downhill funneling and transient mobility. Our results show that the scaling exponents that are associated with mound formation depend continuously on the model parameters.

Interface Profile Near the Contact Line in Electro-wetting on Dielectric

Weiqing Ren(任维清) (National University of Singapore)

We consider a charged droplet sitting on a dielectric substrate and study the static profile of the interface near the contact line. We first derive the governing equations using the principle of minimum energy, then discuss the distinguished limit of the model as the dimensionless parameters β and d go to zero with $d/\beta = O(1)$, where β is the (rescaled) square of the imposed electrical potential and d is the thickness of the insulator. Analysis of the inner problem, which governs the interface profile near the contact line, shows the existence of a well-defined apparent contact angle. Significant bending of the interface is observed near the contact line. The apparent contact angle depends on the applied electrical potential and the thickness of the insulator, and the relation agrees well with the Lippmann-Berge equation. This work was supported by Singapore MOE AcRF grants and NSFC (No.11871365, NUSRI(Suzhou)).

Structure preserving schemes for complex nonlinear systems

Jie Shen(沈捷) (Purdue University&.Xiamen University)

Many complex nonlinear systems have intrinsic structures such as energy dissipation or conservation, and/or positivity/maximum principle preserving. It is desirable, sometimes necessary, to preserve these structures in a numerical scheme.I will first present a new approach to deal with nonlinear terms in a large class of gradient flows and Hamiltonian systems. The approach is not restricted to specific forms of the nonlinear part of the free energy or Hamiltonian. It leads to linear and unconditionally energy stable schemes which only require solving decoupled linear equations with constant coefficients. Hence, these schemes are extremely efficient and very accurate when combined with higher-order BDF schemes. However, this approach, in general, will not preserve positivity or maximum principle.I will then present a strategy to construct efficient energy stable and positivity preserving schemes for certain nonlinear evolution systems, such as the Poisson-Nernst-Planck (PNP) equation and Keller-Segel equation, whose solutions remain to be positive.

Evolution of Microstructure in Polycrystalline Materials

David Srolovitz (University of Pennsylvania)

Polycrystals are ensembles of grains of the same crystal structure that are separated by interfaces across which the crystal orientation changes abruptly. While the motion of such interfaces has classically been modeled by curvature flow and/or other gradient flows, the crystal structure and the solid nature of grains strongly constrains the motion of grain boundaries (GBs). GBs migrate by the motion of line defects constrained to lie within the GB plane that have both dislocation and step character (i.e., disconnections) given by the crystallography. I will review how GBs migrate on the macro and microscopic level and examine how the microscopic (disconnection) mechanisms may be incorporated into continuum description of microstructure evolution.

Implicit boundary integral methods and applications

Yen-Hsi Tsai (University of Texas at Austin)

I will review a general framework that is called the implicit boundary integral methods, which can be applied to a variety of problems that involve non-parametrically represented surfaces.The main idea is to formulate appropriate extensions of a given problem defined on a surface to ones in the narrow band of the surface in the embedding space. The extensions is arranged so that the solutions to the extended problems are equivalent, in a strong sense, to the surface problems that we set out to solve. Such extension approaches allow us to analyze the well-posedness of the resulting system, develop systematically and in a unified fashion numerical schemes for treating a wide range of problems that involve both differential and integral operators, and deal with similar problems in which only point clouds sampling the surfaces are given.We will apply this framework to solve some surface PDE problems, boundary integral equations, and optimal control problems.

Thermodynamically consistent modeling and simulation for interfacial dynamics using phase field models

Qi Wang(王奇) (University of South Carolina)

In many applications, phase transition is induced by temperature change. To model these materials systems using a phase field formulation, care must be taken to make sure the governing system of equations obey the thermodynamical laws as well as nonequilibrium thermodynamical protocols. In this talk, I will present a systematical way to derive such equation systems for nonisothermal multiphase materials systems and discuss their consistent numerical approximations leading to entropy stable schemes. Examples will be given for crystal growth phenomena.

An efficient solver for the coupled Darcy-Stokes system

Weicheng Wang(王伟成) (National Tsinghua University)

We propose an efficient solver for the coupled Darcy-Stokes system modeling the composition of porous media region (Darcy) and free flow region (Stokes).An additional set of interface condition, known as the Beavers-Joseph-Saffman condition, is supplemented on the Darcy-Stokes interface.The coupled system is discretized based on a new weak formulationwhich incorporates the BJS condition naturally without additional regularity requirement.The proposed solver is based on a new preconditioning operator which has a nontrivial component on the interface.The preconditioned system is observed to be uniformly well conditioned independent of mesh size, viscosity or permeability.

Finite time singularity of the nematic liquid crystal flow in dimension two

Juncheng Wei(魏军城) (University of British Columbia)

In this talk I will discuss recent construction of finite time blow-up for the nematic liquid crystal flow in a two-dimensional domain. Let Ω be a two-dimensional domain. We prove that given any k points in Ω there exists a solution (u,d) to the nematic liquid crystal flow equation such that ∇d blows up at these k points with blow-up rate $ \frac{T-t}{\log^2 (T-t)}$. The velocity also blows up but at a much lower rate. This is a joint work with C. Lai, Changyou Wang and Y. Zhou.

On the motion of water waves with angled crests

Sijue Wu (邬似珏) (University of Michigan)

In this talk, I will discuss recent progress concerning the solutions of the full water wave equation, for data that allows for angled crested interfaces. We will show that the water wave equation is locally well-posed in a regime that allows for angled crested interfaces. We will also show that for any data of size ϵ that allows for angled crests, the life span of the solution is at least of order $O(\epsilon^{-3})$.

Energy and Dynamics of Grain Boundaries Based on Underlying Mircrostructure

Yang Xiang(项阳) (Hong Kong University of Science and Technology)

We present continuum models for the energy and dynamics of grain boundaries based on the continuum distribution of the line defects (dislocations or disconnections) on them. The long-range elastic interaction between the line defects is included to maintain a stable grain boundary microstructure. The continuum models is able to describe both normal motion and tangential translation of the grain boundaries due to both coupling and sliding effects that were observed in atomistic simulations and experiments.

Diffusion-dominated pinch-off of ultralow surface tension fluids

Lei Xu(徐磊) (The Chinese University of Hong Kong)

We study the breakup of a liquid thread inside another liquid at different surface tensions. In general, the pinch-off of a liquid thread is governed by the dynamics of fluid flow. However, when the interfacial tension is ultralow (2 to 3 orders lower than normal liquids), we find that the pinch-off dynamics can be governed by bulk diffusion. By studying the velocity and the profile of the pinch-off, we explain why the diffusion-dominated pinch-off takes over the conventional breakup at ultralow surface tensions.

Modeling and Analysis for contact angle hysteresis on rough surfaces

Xianmin Xu(许现民) (Chinese Academy of Science)

Contact angle hysteresis is a complicated wetting phenomenon induced by the inhomogeneity or roughness of the solid surface. There exist stick-slip motions of the three-phase contact line between the two-phase flow interface and the solid boundary. Both numerical simulations and analytical study are very challenging, especially to quantitatively compare with physical experiments. In this talk, we will show some mathematical analysis for the complicated problem. More precisely, we use a phase-field model to study the static and quasi-static problems. We also show that the Onsager principle can be used as a powerful approximation tool to study the dynamic contact angle hysteresis.

Mathematical model for charge transport in nanofluidic problems

Zhenli Xu(徐振礼) (Shanghai Jiaotong University)

We studied structure and dynamics of ions in nanofluidic devices, where dielectric effect plays important role. The ionic cloud surrounding a mobile ion near an interface is tunable due to the force from image charges, thus, the ionic mobility is significantly different from that in region far from the interface. We developed mathematical model to describe the so-called relaxation force by extending the Onsager-Fuoss theory of electrolytes such that the model includes the interfacial effect. Numerical results and analysis are present to show the performance of the model and related methods.

Analysis on the potential theory based Cartesian grid method for interface problems

Wenjun Ying(应文俊) (Shanghai Jiaotong University)

In the past years, we have been working on a potential theory based Cartesian grid method for interface problems. The method solves interface problems on irregular domains with Cartesian grids. It takes advantages of fast elliptic solvers on Cartesian grids and well-conditioning properties of reformulated boundary integral equations. In this talk, I will present some theoretical results on the potential theory based Cartesian grid method for interface problems of the Poisson equation and Stokes equations. Analysis on both stability and accuracy of the method are considered.

4.Participants List

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