Week 10 (Nov.13-Nov.17)

2017 Fall Program on Analysis of PDE
--Conference on Analysis of Complex Fluids

Workshop Room: Room 2001, Guanghua East Building, Fudan University

Invited Speakers:

Shijin Ding
Reinhard Farwig
Eduard Feireisl
Xianpeng Hu
Song Jiang
Chun Liu
Yong Lu
Josef Malek
Nader Masmoudi
Tiezheng Qian
Ping Sheng
Robert Strain
Xiaoming Wang
Xiaoping Wang
Zhouping Xin
Tong Yang
Ping Zhang
Pingwen Zhang
Zhifei Zhang

Organizing Committee:

Peter Constantin (Princeton University)
Yoshikazu Giga (University of Tokyo)
Hao Jia (University of Chicago)
Carlos Kenig (University of Chicago)
Zhen Lei (Fudan University)
Fanghua Lin (Courant Institute of Mathematical Sciences)
Gregory Seregin (University of Oxford)
Vladimir Sverak (University of Minnesota)
Edriss Titi (Texas A & M University)
Sijue Wu (University of Michigan)

Sponsored by

Shanghai Center for Mathematical Sciences
School of Mathematical Sciences, Fudan University

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Schedule

2017 Fall Program on Analysis of PDE (Nov. 13 – Nov. 17, 2017)

Week 10 (Nov.13-Nov.17)	
2017 Fall Program on Analysis of PDE --Conference on Analysis of Complex Fluids	
Monday (November 13)	**Room 2001, Guanghua East Building, Fudan University**
Morning Session	
	Chair：Fanghua Lin
9:30 – 10:20	Pingwen Zhang
10:20 – 10:50	Tea Break
10:50 – 11:40	Nader Masmoudi
Lunch Break	
Afternoon Session	
	Chair: Pingwen Zhang
14:00 – 14:50	Tong Yang
14:50 – 15:20	Tea Break
15:20 – 16:10	Josef Malek
16:10 –17:00	Xianpeng Hu
Tuesday (November 14)	**Room 2001, Guanghua East Building, Fudan University**
Morning Session	
	Chair：Zhouping Xin
9:30 – 10:20	Song Jiang
10:20 – 10:50	Tea Break
10:50 – 11:40	Eduard Feireisl
Lunch Break	

Afternoon Session	
	Chair: Edriss Titi
14:00 – 14:50	Reinhard Farwig
14:50 – 15:20	Tea Break & Group Photo
15:20 – 16:10	Shijin Ding
16:10 –17:00	Tiezheng Qian
17:30	Banquet
Wednesday (November 15)	**Room 2001, Guanghua East Building, Fudan University**
Morning Session	
	Chair：Josef Malek
9:30 – 10:20	Zhouping Xin
10:20 – 10:50	Tea Break
10:50 – 11:40	Ping Sheng
Lunch Break	
Afternoon Session	
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14:00 – 14:50	--
14:50 – 15:20	--
15:20 – 16:10	--
16:10 –17:00	--
Thursday (November 16)	**Room 2001, Guanghua East Building, Fudan University**
Morning Session	
	Chair：Zhen Lei
9:30 – 10:20	Chun Liu
10:20 – 10:50	Tea Break
10:50 – 11:40	Xiaoping Wang
Lunch Break	
Afternoon Session	

	Chair: Eduard Feireisl
14:00 – 14:50	Xiaoming Wang
14:50 – 15:20	Tea Break
15:20 – 16:10	Robert Strain
16:10 –17:00	Yong Lu
Friday (November 17) Room 2001, Guanghua East Building, Fudan University	
Morning Session	
	Chair：Xiaoming Wang
9:30 – 10:20	Ping Zhang
10:20 – 10:50	Tea Break
10:50 – 11:40	Zhifei Zhang
Lunch Break	
Afternoon Session	
14:00 – 17:00	Free

2017 Fall Program on Analysis of PDE

Week 10 (Nov.13- Nov.17)

Conference on Analysis of Complex Fluids

Titles and Abstracts:

Speaker: Shijin Ding
Title: Stability analysis for the incompressible Navier-Stokes equations with Navier boundary conditions
Abstract: This talk is concerned with the instability and stability of the trivial steady states of the incompressible Navier-Stokes equations with Navier-slip boundary conditions in a slab domain in dimension two. The main results show that the stability (or instability) of this constant equilibrium depends crucially on whether the boundaries dissipate energy and the strength of the viscosity and slip length. It is shown that in the case that when all the boundaries are dissipative, then nonlinear asymptotic stability holds true. Otherwise, there is a sharp critical viscosity, which distinguishes the linear and nonlinear stability from instability.

Speaker: Reinhard Farwig
Title: The global attractor for autonomous quasi-geostrophic equations with fractional dissipation in R^2
Abstract: Consider the autonomous surface quasi-geostrophic equation with fractional dissipation in R^2 $\theta_t + u \cdot \nabla\theta + (-\Delta)^\alpha \theta = f(x,\theta)$ in the subcritical case $1/2 < \alpha \leq 1$, with initial condition $\theta(x,0) = \theta^0$ and given external force $f(x,\theta)$. Here the real scalar function θ is the so-called *potential temperature*, and the incompressible velocity field $u = (u_1, u_2) = (-R_2 \theta, R_1 \theta)$ is determined from θ via Riesz operators. Our aim is to prove the existence of the unique global attractor A in the Bessel potential space $H^s(R^2)$ when $s > 2(1 - \alpha)$ and to show that its Hausdorff and fractal dimensions are finite.
The construction of the attractor is based on the existence of an absorbing set in $L^2(R^2)$ as well as in $H^s(R^2)$. A second major step is usually based on compact Sobolev embeddings which unfortunately do not hold for unbounded domains. To circumvent this problem we exploit compact Sobolev embeddings on balls $B_r \subset R^2$ and uniform smallness estimates of solutions on $R^2 \backslash B_r$. In the literature the latter estimates are obtained by a damping term $\lambda\theta$, $\lambda < 0$, as part of the right hand side f to guarantee exponential decay estimates. In our approach we exploit a much weaker nonlocal damping term of convolution type $\rho * \theta$ where ρ is an L^1 function with negative Fourier transform. To prove the finiteness of the dimension of the attractor we use vector-valued estimates for Riesz operators and the fractional Lieb-Thirring inequality.

Speaker: Eduard Feireisl
Title: On regularity properties of the weak solutions to the compressible Euler system
Abstract: We study certain regularity properties of the weak and/or measure-valued solutions of the compressible system, in particular a variant of the so-called Onsager conjecture. This is a joint work with A.Swierczewska-Gwiazda, Piotr Gwiazda and Emil Wiedemann.

Speaker: Xianpeng Hu

Title: Wellposedness of weak solutions to viscoelasticity

Abstract: In this talk, we will discuss some recent progress in the mathematical analysis for the viscoelastic fluid flow. Global existences of weak solutions will be the main subject. The oscillation and concentration of approximating solutions are two main obstacles. A variant of "effective viscous flux" turns again to be a key tool to deal with the weak stability.

Speaker: Song Jiang

Title: TBA

Abstract: TBA

Speaker: Chun Liu

Title: General Diffusion in Biological Environments

Abstract: Almost all biological activities involve transport and distribution of ions and charged particles. The complicated coupling and competition between different ionic solutions in various biological environments give the intricate specificity and selectivity in these systems. In this talk, I will introduce several extended general diffusion systems motivated by the study of ion channels and ionic solutions in biological cells. In particular, I will focus on the interactions between different species, the boundary effects and in many cases, the thermal effects.

Speaker: Yong Lu

Title: On a compressible Oldroy-B model: relative entropy, weak-strong uniqueness and conditional regularity

Abstract: We consider the compressible Oldroyd-B model derived in \cite{Barrett-Lu-Suli16}, where the existence of global-in-time finite-energy weak solutions was shown in two dimensional setting. Still in the two dimensional setting, we give a (refined) blow-up criterion involving only the upper bound of the fluid density. We then show that, if the initial fluid density and polymer number density admit a positive lower bound, the weak solution coincides with the strong one as long as the latter exists. Moreover, if the fluid density of a weak solution issued from regular initial data admits a finite upper bound, this weak solution is indeed a strong one; this can be seen as a corollary of the refined blow-up criterion and the weak-strong uniqueness.

Speaker: Josef Malek

Title: PDE analysis of a class of thermodynamically compatible viscoelastic rate-type fluids with stress diffusion

Abstract: We establish the long-time existence of large-data weak solutions to a system of nonlinear partial differential equations. The system of interest governs the motion of non-Newtonian fluids described by a simplified viscoelastic rate-type model with a stress-diffusion term. The simplified model shares many qualitative features with more complex viscoelastic rate-type models that are frequently used in the modeling of fluids with complicated microstructure. As such, the simplified model provides important preliminary insight into the mathematical properties of these more complex and practically relevant models of non-Newtonian fluids. The simplified model that is analyzed from the mathematical perspective is shown to be thermodynamically consistent, and we extensively comment on the interplay between the thermodynamical background of the model and the mathematical analysis of the corresponding initial-boundary-value problem. This is a joint work with Miroslav Bulicek, Vit Prusa and Endre Suli.

Speaker: Nader Masmoudi
Title: TBA
Abstract: TBA

Speaker: Tiezheng Qian
Title: Reciprocal theorem: From local equations to symmetry over the whole system
Abstract: Onsager's reciprocal symmetry is typically used to derive local constitutive equations through a variational approach. We consider a non-equilibrium system close to the global equilibrium state. We show that the reciprocal symmetry for local constitutive equations can be extended to a new symmetry over the whole system. This symmetry is manifested in the kinetic coefficients connecting the forces and fluxes defined at the system boundary. Our results generalize the Lorentz theorem for Stokes flows.

Speaker: Ping Sheng
Title: Numerical Study of Single Particle Electrophoresis
Abstract: When immersed in an electrolyte solution, colloidal particles usually acquire surface charges due to either the adsorption of ions onto the particle surface or ionization of dissociable surface groups. An ionic cloud is formed around each particle as a result, denoted the Debye layer that serves to screen the net surface charges. When an external electric field is applied to such a suspension, there can be steady motion of the particles. This is known as the electrophoresis effect. The physical picture underlying the electrophoresis effect can be dated back to Smoluchowski, who divided the flow field around the charged particle into an inner region consisting of an electrical double layer, plus an outer region which is basically electro-neutral in character. While the general framework of the Smoluchowski picture is correct, many open questions remain. For example, where precisely is the interface between the inner and outer regions? Is the interfacial boundary sharp, in terms of the flow field? Also, since the Debye layer does not end abruptly, can there be remnant unscreened charge contributing to the electrophoretic force balance? Moreover, direct measurements of the drag force under electric field were rare. In most cases, the electrophoretic mobility was the only measured quantity, and either the standard theory or indirect chemical methods, i.e. titration, were used to estimate the bare particle charge and the zeta potential.
We present an extensive numerical study of single spherical particle electrophoretic dynamics using the Poisson-Nernst-Planck equations, coupled with the Navier-Stokes equation. This is not only interesting from a fundamental colloid science point of view; the study also gives a clear physical definition of the boundary which separates the inner and outer flow fields, as well as its role in accounting for the measured drag coefficient and effective charge. The latter poses challenges to the traditional definition of effective charges. Our numerical solution of the electrophoretic flow shows that the flow field associated with an electrophoretic microsphere comprises two distinct flow regions. There is an inner flow region in which the mobile ions in the Debye layer, driven by the electric field, can generate a ring of electro-hydrodynamic vortices around the equatorial plane of the spherical particle, perpendicular to the field direction. This inner flow field is joined to an outer flow region in which the flow pattern corresponds well with that of the known far-field solution of the electrophoretic flow, i.e., liquid velocity $u \propto 1/r^3$, with r being the radial distance from the center of the sphere.
The existence of the vortices in the inner flow region is somewhat surprising, since the relevant Reynold number is extremely small. We show that in the present case the vorticity is generated by the large local

electric field in the Debye layer, instead of the traditional inertial term in the Navier Stokes equation. The effective surface charge acted on by the applied electric field is shown to agree well with the value of the net charge evaluated at the interface between the inner and outer flows. This effective charge is much smaller than the true surface charge because of the screening by the mobile ions in the Debye layer. As a test of consistency, the calculated drag coefficient is found to agree well with that evaluated numerically at the same interface.

*Work done in collaboration with Maijia Liao, Ming-Tzo Wei, Shixin Xu, and H. Daniel Ou-Yang

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Speaker: Robert Strain

Title: On the Muskat problem with viscosity jump: global in time results

Abstract: This talk is about the Muskat problem, modeling the filtration of two incompressible immiscible fluids in porous media. We consider the case in which the fluids have different constant densities together with different constant viscosities. In this situation the equations are non-local, not only in the evolution system, but also in the implicit relation between the amplitude of the vorticity and the free interface. Among other extra difficulties, no maximum principles are available for the amplitude and the slopes of the interface in L^∞. We prove global in time existence results for medium size initial stable data in critical spaces. We also improved previous methods showing smoothing (instant analyticity) together with sharp decay rates of analytic norms for a more general class of initial data. The found technique is twofold, giving ill-posedness in unstable situations for lower regularity solutions.

Speaker: Xiaoming Wang

Title: Coupling and decoupling of flows in conduit and flows in porous media

Abstract: We consider the Navier-Stokes-Darcy system that describes the motion of fluids in conduits coupled with flows in surrounding porous media via appropriate interface boundary conditions. The system is highly non-linear and strongly coupled. After discussing the well-posedness of the system, we present a linear, uniquely solvable and long-time energy stable scheme that decouples the Navier-Stokes equations from the Darcy equation. Such kind of long-time stable algorithms are highly desirable for the physically significant small Darcy number regime if we are interested in the important transport behavior in porous media. Next, we investigate the behavior of the Navier-Stokes-Darcy system at small Darcy number and we discover that the leading order dynamics are completely decoupled.

Speaker: Xiao-Ping Wang

Title: A threshold dynamics method for interface motion

Abstract: The threshold dynamics method developed by Merriman, Bence and Osher(MBO) is an efficient method for simulating the motion by mean curvature flow when the interface is away from the solid boundary. Direct generalization of the MBO type method to the wetting problems with interface intersecting the solid boundary is not easy because solving heat equation on general domain with wetting boundary condition is not as efficient as that for the original MBO method. The dynamics of the contact point also follows a different dynamic law compared to interface dynamics away from the boundary. We develop an efficient volume preserving threshold dynamics (MBO) method for drop spreading on rough surfaces. The method is based on minimization of the weighted surface area functional over an extended domain that includes the solid phase. The method is simple, stable with the complexity O(N log N) per time step and it is not sensitive to the inhomogeneity or roughness of the solid boundary. We also extend the idea to an efficient method for image segmentation.

Speaker: Zhouping Xin
Title: TBA
Abstract: TBA

Speaker: Tong Yang
Title: TBA
Abstract: TBA

Speaker: Ping Zhang
Title: TBA
Abstract: TBA

Speaker: Pingwen Zhang
Title: Generalized De Giorgi Conjecture in the Isotropic-Nematic Phase Transition
Abstract: In this talk, I will first introduce De Giorgi conjecture, which states that the level sets must be hyperplanes for any bounded solution of the Allen-Cahn equation under a monotonicity assumption. This equation arises in the multi-phase system. Next I will introduce the isotropic-nematic phase transition problem in liquid crystal based on the Landau-de Gennes (Q-tensor) energy. The associated Euler-Lagrange equation is similar to the Allen-Cahn equation. However, the order parameter is a symmetric traceless matrix. For this system, we propose a generalized De Giorgi conjecture. Finally, I will present some recent progress on the isotropic-nematic phase transition problem.

Speaker: Zhifei Zhang
Title: TBA
Abstract: TBA

Participants:

Dongfen Bian (Beijing Institute of Technology)
Yuan Cai (Fudan University)
Tuowei Chen (Fudan University)
Xiufang Cui (Fudan University)
Shijin Ding (South China Normal University)
Reinhard Farwig (Technical University of Darmstadt)
Eduard Feireisl (Czech Academy of Sciences)
Zaihui Gan (Tianjin University)
Daoyin He (Fudan University)
Bobo Hua (Fudan University)

Xianpeng Hu (City University of Hongkong)
Song Jiang (Institute of Applied Physics and Computational Mathematics)
Zhentao Jin (Fudan University)
Zhen Lei (Fudan University)
Hui Li (Peking University)
Jinkai Li (Chinese University of Hong Kong)
Fanghua Lin (Courant Institute)
Chun Liu (Penn State University)
Guowei Liu (Shanghai Jiao Tong University)
Song Liu (The Chinese Academy of Sciences)
Yanlin Liu (The Chinese Academy of Sciences)
Yong Lu (Nankai University)
Junren Luo (Fudan University)
Josef Malek (Charles University in Prague)
Nader Masmoudi (New York University, Courant Institute)
Jianzhong Min (Fudan University)
Yun Pu (Fudan University)
Tiezheng Qian (Hong Kong University of Science and Technology)
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