International Conference on the Mathematical Fluid Dynamics on the occasion of Professor Yoshihiro Shibata's 60th birthday

March 5–9, 2013

Program & Abstract

Hotel Nikko Nara, Nara, Japan

Date

March 5–9, 2013

Conference Venue

Hotel Nikko Nara, Nara, Japan

Science Committee

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Sponsors

- JSPS Grant No. 24224003, Mathematical theory of turbulence by the method of modern analysis and computational science (Hideo Kozono)
- JSPS Grant No. 24224004, Construction of to investigate the fluid structure from the macroscopic view point and the mesoscopic view point (Yoshihiro Shibata)
- JSPS Grant No. 24340025, Maximal regularity and its application to free boundary problems for fluids with thermodynamic equilibrium (Senjo Shimizu)
- JSPS-DFG The Japanese-German Graduate Externship ”Mathematical Fluid Dynamics”

– PROGRAM –

March 5 (Tue)

9:00∼9:15	Registration
9:20∼	Opening : Hideo Kozono (*Waseda University*)
9:30∼10:00	Herbert Amann (*University of Zurich*) Parabolic Equations on Non-compact Riemannian Manifolds
10:05∼10:35	Giovanni P. Galdi (*University of Pittsburg*) On Time-Periodic Flow of a Viscous Liquid past a Moving Cylinder
10:55∼11:25	Yasushi Taniuchi (*Shinshu Univ.*) Uniqueness of backward asymptotically almost periodic-in-time solutions to Navier-Stokes equations in unbounded domains
11:30∼12:00	Marco Cannone (*Université Paris-Est*) Well-posedness of the Prandtl equation with incompatible data
12:00∼14:00	Free Disccusion
14:00∼14:30	Paolo Secchi (*Brescia Univ.*) On the well-posedness of the free plasma-vacuum interface problem
14:35∼15:05	Yasunori Maekawa (*Kobe Univ.*) Long-time asymptotics for two-dimensional exterior flows with small circulation at infinity
15:10∼15:40	Adélia Sequeira (*Technical Univ. Lisbon*) Recent trends in the mathematical modeling of blood coagulation
16:10∼16:40	Gieri Simonett (*Vanderbilt University*) On a thermodynamically consistent Stefan problem with variable surface energy
16:45∼17:15	Dieter Bothe (*TU Darmstadt*) A thermodynamically consistent model for chemically reacting multicomponent fluid systems

March 6 (Wed)

9:30∼10:00	Hugo Beirão da Veiga (*Pisa Univ.*) On the singular p-Laplace system under Navier slip type
10:05∼10:35	Gregory Seregin (*Oxford Univ.*) The behavior of L_3-norm of solutions to the Navier-Stokes equations as time approaches a possible blowup
10:55∼11:25	Michael Růžička (*Univ. Freiburg*) Problems with p-structure: analysis and numerics
11:30∼12:00	Joseph Málek (*Charles University in Prague*) On implicitly constituted incompressible fluids
12:00∼14:00	Free Disccusion
14:00∼14:30	Eduard Feireisl (*Acad. Sci. Prague*) Dissipative solutions to the full Navier-Stokes-Fourier system
14:35∼15:05	Milan Pokorny (*Charles University in Prague*) Steady compressible Navier-Stokes–Fourier system
15:10∼15:40	Šárka Nečasová (*Mathematical Institute, Academy of Sciences*) Compresible barotropic fluids in time-dependent domains: existence and incompressible limits
16:10∼16:40	Edriss S. Titi (*Weizmann Institute & University of California*) The Three-Dimensional Euler Equations: Recent Advances
16:45∼17:15	Shinya Nishibata (*Tokyo Institute of Technology*) Boundary layer solution to the hyperbolic-parabolic system

March 7 (Thu)

9:30∼10:00	John G. Heywood (*University of British Columbia*) Seeking an improved regularity theory for the Navier-Stokes equations via the conjectured ‘Xie’s inequality’
10:05∼10:35	Reinhard Farwig (*Technische Universität Darmstadt*) How (fast) do solutions of the Boussinesq system decay?
10:55∼11:25	Norikazu Yamaguchi (*Univ. of Toyama*) Mathematical justification and error estimate for the penalty method of the Navier-Stokes equations
11:30∼12:00	Jiří Neustupa (*Czech Academy of Sciences, Prague*) A refinement of some regularity criteria for weak solutions of the Navier–Stokes equations
12:00∼14:00	Free Disccusion
14:00∼15:30	Poster Section
18:30∼	Banquet and Free Discussion

–POSTER SECTION–

Ken Abe (*The University of Tokyo*)
On the uniqueness of the Stokes flow in half space with singularity at time zero

Lorenz Von Below (*Waseda Univ./TU Darmstadt*)
On free boundary value problems related to the spin coating system

Jan Brezina (*Kyushu Univ.*)
Asymptotic behavior of solutions to the compressible Navier-Stokes equation around a time-periodic parallel flow

Motofumi Hattori (*Kanagawa Institute of Technology*)
A numerical oscillation problem of particle method MPS

Takahito Kashiwabara (*Univ. of Tokyo*)
On a strong solution of the Navier-Stokes equations under slip or leak boundary conditions of friction type

Daniel Lengeler (*Regensburg University*)
Global weak solutions for the interaction of a viscous incompressible fluid with a Koiter shell

Giusy Mazzone (*Pittsburgh Univ.*)
Zhukovskii's Conjecture for the Motion of a Rigid Body Filled with a Viscous Fluid

Miho Murata (*Waseda Univ.*)
On the sectorial $\mathscr{R}$-boundedness of the Stokes operator for the compressible viscous fluid flow in a general domain

Tomoyuki Nakatsuka (*Nagoya Univ.*)
Uniqueness of steady Navier-Stokes flows in exterior domains

Masashi Ohnawa (*Waseda Univ.*)
Nonlinear stability of plasma boundary layers with fluid-boundary interaction

Issei Oikawa (*Waseda Univ.*)
Numerical analysis of the flow around a circular cylinder

Hirokazu Saito (*Waseda Univ.*)
On the maximal regularity of the Stokes problem with the Neumann-Robin boundary condition in an infinite layer

Masahiro Suzuki (*Tokyo Institute of Technology*)
Asymptotic behavior of solutions to a shallow water model

Ryo Takada (*Kyoto University*)
Dispersive estimates for the Navier-Stokes equations in the rotational framework

Yutaka Terasawa (*The University of Tokyo*)
On a diffuse interface model for non-Newtonian two phase flows with matched densities

March 8 (Fri)

9:30∼10:00	Jan Prüss (*Universität Halle*) Two-Phase Flows with Phase Transitions
10:05∼10:35	Konstantin Pileckas (*Vilnius University*) On the stationary Navier-Stokes system with non-homogeneous boundary data
10:55∼11:25	Piotr Mucha (*University of Warsaw*) Inhomogeneous Navier-Stokes equations and jumps of density
11:30∼12:00	Helmut Abels (*University Regensburg*) On Sharp Interface Limits for Diffuse Interface Models
12:00∼14:00	Free Disccusion
14:00∼14:30	Paolo Maremonti (*Seconda Unicersità degli Studi di Napoli*) High regularity of solutions to modified p-Stokes equations
14:35∼15:05	Takayuki Kubo (*Univ. of Tsukuba*) Weighted $L^p - L^q$ estimates of Stokes semigroup in exterior domains
15:25∼15:55	Robert Denk (*University of Konstanz*) Maximal regularity for mixed-order systems
16:00∼16:30	Matthias Hieber (*TU Darmstadt*) The Resolvent Approach to the Stokes Equation on $L^\infty(\Omega)$
16:35∼	Closing : Hideo Kozono (*Waseda University*)

March 9 (Sat)

Scientific Free Discussion

– ABSTRACT –

INVITED TALKS

On Sharp Interface Limits for Diffuse Interface Models

Helmut Abels
University Regensburg, Germany

We consider the flow of two partly miscible viscous incompressible Newtonian fluids and study the limes when a certain parameter $\varepsilon > 0$ tends to zero. The parameter ε is proportional to the "interface thickness" of the diffuse interface between the fluids. We will discuss recent analytic results on the question under which conditions a classical diffuse interface model for the flow of two viscous, incompressible fluids converges to the known sharp interface models. In particular we will present negative and positive results in dependence on the scaling of the mobility in the sharp interface limit. We will partly restrict ourselves to the case of a convective Cahn-Hilliard equation, which is part of the full system.

Parabolic Equations on Non-compact Riemannian Manifolds

Herbert Amann
University of Zurich, Germany

We discuss linear parabolic equations on non-compact Riemannian manifolds. It turns out that they possess the property of maximal regularity in weighted Sobolev spaces, where the weight is related to the underlying geometry.
The general results apply, in particular, to domains with singularities, which motivated this research.

On the singular p-Laplace system under Navier slip type

Hugo Beirão da Veiga
Pisa Univ., Italy

We consider the p-Laplace system of N equations in n space variables, $1 < p \leq 2$, under the Navier slip boundary condition. Furthermore, the gradient of the velocity is replaced by the, more physical, symmetric gradient. We prove $W^{2,q}$ regularity, up to the boundary, under suitable assumptions on the couple p, q. The singular case $\mu = 0$ is covered.

A thermodynamically consistent model for chemically reacting multicomponent fluid systems

Dieter Bothe
TU Darmstadt, Germany

Multicomponent diffusion in fluid systems is commonly modeled via the Maxwell-Stefan equations. This approach is also employed for chemically reacting systems, but the standard derivation does not cover this case. This contribution provides a rigorous deduction of the Maxwell-Stefan equations together with an extension to chemically reactive mixtures. The derivation is based on partial balances in particular of the species momenta, where the entropy principle is exploited to obtain information on the inter-species momentum transfer. This yields a closed system of partial mass and momentum balances, from which the system of (extended) Maxwell-Stefan equations follows in the diffusional approximation. The latter is derived from entropy considerations, since the usual scale-separation argument is not feasible in the chemically reactive case.

Joint work with Wolfgang Dreyer, WIAS (Berlin, Germany)

Well-posedness of the Prandtl equation with incompatible data

Marco Cannone
Université Paris-Est, France
joint work with Maria Carmela Lombardo and Marco Sammartino

We will prove that the solution u^P of the Prandtl equation with incompatible initial and boundary data can be written in the following form: $u^P = u^S + u^R + w_1$. Here the singular part u^S solves a heat equation with incompatible data and has the form of an error function, whereas the u^R term is the solution of the Prandtl equation with regular data and will be constructed using the techniques introduced in a previous paper by the same authors (Siam J. Math. Anal, **35** (4), 987–1004, 2003). Finally, w_1 is a term that takes into account the interaction between the singular and the regular part of u^P and solves a Prandtl equation with homogeneous initial and boundary data and with a source term.

Maximal regularity for mixed-order systems

Robert Denk
University of Konstanz, Germany

Maximal regularity in L^p-spaces is one of the main tools to proof local well-posedness of nonlinear parabolic equations. In several applications, mixed-order systems appear in a natural way, e.g. in thermoelastic plate models. We will discuss methods and results on maximal L^p-regularity for general mixed-order systems, concentrating first on the whole-space case. Here one obtains even the existence of a bounded H^∞-calculus for parabolic mixed-order differential and pseudodifferential systems.

For boundary value problems, the proof of maximal regularity may be based on the concept of $\mathscr{R}$-boundedness. Several results are available for the classical thermoelastic plate equation where also energy decay estimates of the solution can be shown. Further applications include the spin-coating process and the Stokes equation in cylindrical domains.

How (fast) do solutions of the Boussinesq system decay?

Reinhard Farwig
Technische Universität Darmstadt, Germany

In this joint work with Raphael Schulz (University of Erlangen-Nürnberg) and Masao Yamazaki (Waseda University, Tokyo) we study in the whole space $\mathbb{R}^n$ the behaviour of solutions to the Boussinesq system at large distances. Therefore, we investigate the solvability of these equations in weighted L^∞-spaces and determine the asymptotic profile for sufficiently fast decaying initial data. For $n = 2,3$ we are able to construct initial data such that the velocity exhibits an interesting *concentration-diffusion phenomenon*:

Given arbitrary epochs $0 < t_1 < \dots t_N$ we find t_i', t_i'' arbitrarily close to t_i such that the decay of u switches between $|u(x,t_i')| \leq \frac{c}{|x|^{n+1}}$ (concentration) and $|u(x,t_i'')| \geq \frac{c}{|x|^n}$ (diffusion), $1 \leq i \leq N$. We will explain the flow pattern of the leading term responsible for this unexpected physical phenomenon.

Dissipative solutions to the full Navier-Stokes-Fourier system

Eduard Feireisl
Acad. Sci. Prague, Czech Republic

We introduce a new concept of the so-called dissipative solution to the full Navier-Stokes-Fourier system and discuss its basic properties. As corollaries of the theory, we discuss applications to the problem of weak-strong uniqueness and inviscid incompressible limits.

On Time-Periodic Flow of a Viscous Liquid past a Moving Cylinder

Giovanni P. Galdi
University of Pittsburg, USA

Consider a cylinder, $\mathscr{C}$, moving in an unlimited mass of viscous liquid, in a direction perpendicular to its axis a, with prescribed velocity $-v_\infty = -v_\infty(t)$. It is assumed that the function $v_\infty(t)$ is periodic of period T. In a region of flow sufficiently far from the two ends of $\mathscr{C}$ and including $\mathscr{C}$, one expects that the velocity field of the liquid is independent of the coordinate parallel to a and, moreover, that there is no flow in the direction of a. Under these conditions, the motion of the liquid will then be two-dimensional and take place in a plane orthogonal to a.

The question that we will address in this talk is simply formulated as follows. *Will the planar motion of the liquid be periodic as well, with period T ?*

As is well known, a mathematical analysis of the problem was initiated by G.G. STOKES in his classical 1851 paper. There, under the assumptions of "creeping flow", namely, disregarding the nonlinear term in the Navier-Stokes equations, and of a circular cross section STOKES was able to give a positive answer to the question, along with a complete description of the flow field. Such a successful result might seem, at first sight, at odds with what STOKES shows a few pages later, that is, that the analogous steady-state problem does not have a solution (*Stokes Paradox*). These two results are at variance if one thinks of "steady-state" as a particular case of "time-periodic", which, of course, need not always be the case.

Objective of this talk is to provide a fully nonlinear analysis of the above problem and to show, under suitable assumptions of the data, the existence, uniqueness and spatial asymptotic behavior of a time periodic solution.

Seeking an improved regularity theory for the Navier-Stokes equations via the conjectured 'Xie's inequality'

John G. Heywood
University of British Columbia, Republic of Colombia

It is now thirty years since I began an effort to free the regularity theory for the nonstationary Navier-Stokes equations from global assumptions about the regularity of the boundary by seeking an inequality of the form $\sup_\Omega |u|^2 \leq c \|\nabla u\| \left\|\widetilde{\triangle} u\right\|$, with a constant c which is independent of the regularity of the boundary. Here u is a divergence free vector field that vanishes on the boundary of a three-dimensional domain Ω; $\|\cdot\|$ is the L^2-norm; and $\widetilde{\triangle}$ is the Stokes operator. If proven, this inequality could replace the use of the inequality $\|u\|_{2,2} \leq c_\Omega \left\|\widetilde{\triangle} u\right\|$ at key points of the theory. It is well known that the constant c_Ω in this inequality depends on the regularity of the boundary. My overall goal seemed near at hand in 1992, when my student Wenzheng Xie gave a proof of the desired new inequality modulo one point that he left as a conjecture, a very likely looking conjecture. His argument is in all other respects valid for an arbitrary open set $\Omega \subset R^3$ and provides an explicit value for the constant, $c = (3\pi)^{-1}$, which is shown to be optimal for any domain. Following Xie's work on this problem, I have returned to it from time to time, proposing a sequence of alternative conjectures with which to complete Xie's argument. Xie's argumentation has also been explored in the context of other problems, firstly by Xie himself in proving an analogous inequality for the Poisson problem, and recently by myself in proving some inequalities for Fourier series.

The Resolvent Approach to the Stokes Equation on $L^\infty(\Omega)$

Matthias Hieber
TU Darmstadt, Germany

In this talk we consider the linear Stokes equation on spaces of bounded functions for certain classes of domains $\Omega \subset \mathbb{R}^n$ for $n \geq 2$. Inspired by the Masuda-Stewart technique for elliptic operators, we show a priori estimates of L^∞-type for the Stokes resolvent equation provided Ω is a strictly admissable and uniformly C^2-domain.

These estimates imply in particular that the Stokes operator generates an analytic semigroup on $C_{0,\sigma}(\Omega)$ of angle $\pi/2$ provided Ω is of the above form. Moreover, the Stokes operator generates an analytic semigroup on $L^\infty_\sigma(\Omega)$ of angle $\pi/2$ provided Ω is a bounded or exterior domain of class C^3.

This is joint work with K. Abe and Y. Giga.

Weighted $L^p - L^q$ estimates of Stokes semigroup in exterior domains

Takayuki Kubo
Univ. of Tsukuba, Japan

We consider the Navier-Stokes equations in exterior domains and in the weighted L^p space. For this purpose, we shall prove the $L^p - L^q$ estiamtes of Stokes semigroup with weigh $\langle x\rangle^s$ type. Our proof is based on the cut-off technique with local energy decay estimate proved by Dan, Kobayashi and Shibata and the weighted $L^p - L^q$ estimates of Stokes semigroup in the whole space proved by Kobayashi and Kubo. Finally, as the application of the weighted $L^p - L^q$ estimates to the Navier-Stokes equations, we obtain the weighted aysmptotic behavior of global solution as $t \to \infty$. This is joint work with Takayuki Kobayashi(Saga Univ.).

Long-time asymptotics for two-dimensional exterior flows with small circulation at infinity

Yasunori Maekawa
Kobe Univ., Japan

We consider the viscous incompressible flows in a two-dimensional exterior domain with no-slip boundary conditions. We will show that if the initial vorticity is sufficiently localized and the circulation number is sufficiently small then the solution asymptotically converges to the self-similar Oseen vortex at time infinity. This is a global stability result, in the sense that the perturbation from the Oseen vortex may be arbitrarily large. This talk is based on a joint work with Thierry Gallay (Grenoble, France).

On implicitly constituted incompressible fluids

Joseph Málek
Charles University in Prague, Czech Republic

We study flows of incompressible fluids in which the deviatoric part of the Cauchy stress and the symmetric part of the velocity gradient are related through an implicit equation. Although we restrict ourselves to responses characterized by a maximal monotone graph, the structure is rich enough to include power-law type fluids, stress power-law fluids, Bingham and Herschel-Bulkley fluids, etc. We are interested in the development of (large-data) existence theory for internal flows of such fluids subject to various type of boundary conditions. We show, in particular, that the implicit relations on the boundary can have a significant impact on the development of the mathematical theory even for the Navier-Stokes equations and its generalization.

References

[1] M. Bulíček, P. Gwiazda, J. Málek, A. Świerczewska-Gwiazda: On unsteady flows of implicitly constituted incompressible fluids, *SIAM J. Math. Anal.*, Vol. 44, No. 4, pp. 2756–2801 (2012)

[2] M. Bulíček, P. Gwiazda, J. Málek, A. Świerczewska-Gwiazda, K.R. Rajagopal: On flows of fluids described by an implicit constitutive equation characterized by a

maximal monotone graph, in: *Mathematical Aspects of Fluid Mechanics* (eds. J.C. Robinson, J. L. Rodrigo and W. Sadowski), London Mathematical Society Lecture Notes Series 402, Cambridge University Press, pp. 23–51 (2012)

High regularity of solutions to modified p-Stokes equations

Paolo Maremonti
Seconda Unicersità degli Studi di Napoli, Italy

We consider the following modified Stokes system

$$\nabla \cdot (|\nabla u|^{p-2}\nabla u) - \nabla \pi = f,\ \nabla \cdot u = 0 \text{ in } \mathbb{R}^n,\ n \geq 3, \tag{1}$$

in the singular case $p \in (1,2)$. This kind of system was considered for the first time in the sixties by Ladyzhenskaya and by Lions, and subsequently it was studied by several authors in connection with fluid-dynamic models. In connection with problem (1) we are able to prove

Theorem - *Let $p \in (p_0, 2]$, and $q_1 = \frac{np}{n+p}$. Then there exist a range of exponents $q(p) > n$ such that for all $f \in J^{q_1}(\mathbb{R}^n) \cap J^q(\mathbb{R}^n)$ problem (1) admits, in the sense of the distributions, a solution $u \in J^{\frac{np}{n-p}}(\mathbb{R}^n)$ with $D^2u \in L^{q_1}(\mathbb{R}^n) \cap L^q(\mathbb{R}^n)$. The corresponding pressure π belongs to $L^{p'}(\mathbb{R}^n) \cap W^{1,q}(\mathbb{R}^n)$. Finally, (u,π) is unique in the class of weak solutions.*

The above theorem gives sufficient conditions for high regularity of solutions, in the sense of L^q integrability, $q \in (n,\infty)$, of second derivatives. As far as we know these are the first high regularity results obtained for problems of p-Stokes kind and, by embedding, they give also the first $C^{1,\alpha}$-regularity results of solutions.

The results are part of the paper:

F. Crispo and P.M., *High regularity of solutions to modified p-Stokes equations, forthcoming*.

Inhomogeneous Navier-Stokes equations and jumps of density

Piotr Mucha
University of Warsaw, Poland

I plan to talk about minimal assumptions on regularity of the initial density for the issue of the well posedness to the inhomogeneous Navier-Stokes system for incompressible flows with variable density. Thanks to an approach via the Lagrangian coordinate system we are able to show the existence of unique solutions with positive L_∞ initial density, admitting arbitrary jumps. For global in time existence we are obligated to assume same smallness conditions. The talk will be based on results joint with Raphael Danchin (Paris): R. Danchin, P.B. Mucha: A Lagrangian Approach for the Incompressible Navier-Stokes Equations with Variable Density, CPAM 65, 2012,14581480

R. Danchin, P.B. Mucha: Incompressible flows with piecewise constant density, ARAM (2012,online) arXiv:1203.1131.

Compresible barotropic fluids in time-dependent domains: existence and incompressible limits

Šárka Nečasová

Mathematical Institute, Academy of Sciences, Czech Republic

We consider the compressible Navier- Stokes equations in time dependent domain with Navier type of boundary conditions. We prove that low Mach number limit in time dependent domains is the incompressible Navier Stokes with Navier type of boundary conditions in time dependent domain. It is a joint work with E. Feireisl, O. Kreml, J. Neustupa and J. Stebel.

A refinement of some regularity criteria for weak solutions of the Navier–Stokes equations

Jiří Neustupa

Czech Academy of Sciences, Prague, Czech Republic

We present several new criteria for regularity of a suitable weak solution to the Navier-Stokes initial-boundary value problem. One of them uses an assumption on the Serrin-type integrability of velocity in a part of a backward parabolic neighbourhood of point (x_0,t_0): the considered part is an exterior of certain space-time paraboloid with vertex at the point (x_0,t_0), intersected with the backward parabolic neighbourhood. Another criterion imposes conditions on certain spectral projection of vorticity or only on one its component.

Boundary layer solution to the hyperbolic-parabolic system

Shinya Nishibata

Tokyo Institute of Technology, Japan

We consider a large-time behavior of solutions to symmetric hyperbolic-parabolic systems in a half line. We firstly prove the existence of a boundary layer, which is a stationary solution, by assuming that a boundary strength is sufficiently small. Especially, in the case where one eigenvalue of Jacobian matrix appeared in a stationary problem becomes zero, we assume that the characteristics field corresponding to the zero eigenvalue is genuinely non-linear in order to show the existence of a degenerate stationary solution with the aid of a center manifold theory. We next prove that the stationary solution is time asymptotically stable under a smallness assumption on the initial perturbation. The key to proof is to derive the uniform a priori estimates by using the energy method.

The present results are based on the joint research with Dr. Tohru Nakamura at Kyushu University.

On the stationary Navier-Stokes system with non-homogeneous boundary data

Konstantin Pileckas
Vilnius University, Lithuania

We study the nonhomogeneous boundary value problem for the Navier–Stokes equations

$$\begin{cases} -\nu\Delta\mathbf{u} + \big(\mathbf{u}\cdot\nabla\big)\mathbf{u} + \nabla p &= 0 \qquad \text{in } \Omega, \\ \operatorname{div}\mathbf{u} &= 0 \qquad \text{in } \Omega, \\ \mathbf{u} &= \mathbf{a} \qquad \text{on } \partial\Omega \end{cases} \tag{1}$$

in a plane bounded multiply connected domain $\Omega = \Omega_1 \setminus \Omega_2$, $\overline{\Omega}_2 \subset \Omega_1$.

Starting from the famous J. Leray's paper published in 1933, problem (1) was a subject of investigation in many papers. The continuity equation in (1) implies the necessary solvability condition

$$\int\limits_{\partial\Omega} \mathbf{a}\cdot\mathbf{n}\,dS = \sum_{j=1}^{2} \int\limits_{\partial\Omega_j} \mathbf{a}\cdot\mathbf{n}\,dS = 0, \tag{2}$$

where $\mathbf{n}$ is a unit vector of the outward (with respect to Ω) normal to $\partial\Omega$. However, for a long time the existence of a weak solution $\mathbf{u} \in W^{1,2}(\Omega)$ to problem (1) was proved only under the stronger condition

$$\mathscr{F}_j = \int\limits_{\partial\Omega_j} \mathbf{a}\cdot\mathbf{n}\,dS = 0, \qquad j = 1,2. \tag{3}$$

It will be proved in the talk that this problem admits at least one solution if the flux $\mathscr{F} = \int\limits_{\partial\Omega_2} \mathbf{a}\cdot\mathbf{n}\,dS = -\int\limits_{\partial\Omega_1} \mathbf{a}\cdot\mathbf{n}\,dS$ of the boundary value $\mathbf{a}$ through $\partial\Omega_2$ is nonnegative (outflow condition). The result was obtain in the joint paper with M. Korobkov and R. Russo.

References:

1. M.V. Korobkov, K.Pileckas, R. Russo, On the Flux Problem in the Theory of Steady Navier-Stokes Equations with Nonhomogeneous Boundary Conditions, *Arch. Rational Mech. Anal.*, DOI: 10.1007/s00205-012-0563-y (2012).

Steady compressible Navier-Stokes–Fourier system

Milan Pokorny
Charles University in Prague, Czech Republic

We consider the system of partial differential equations in $\Omega \subset \mathbb{R}^3$

$$\operatorname{div}(\rho\mathbf{u}) = 0, \tag{2}$$

$$\operatorname{div}(\rho\mathbf{u}\otimes\mathbf{u}) - \operatorname{div}\mathbb{S} + \nabla p = \rho\mathbf{f}, \tag{3}$$

$$\operatorname{div}(\rho E\mathbf{u}) = \rho\mathbf{f}\cdot\mathbf{u} - \operatorname{div}(p\mathbf{u}) + \operatorname{div}(\mathbb{S}\mathbf{u}) - \operatorname{div}\mathbf{q} \tag{4}$$

which describes steady flow of a heat conducting compressible fluid in a bounded domain Ω. We consider (2)–(4) together with the boundary conditions at $\partial\Omega$

$$\begin{aligned} \mathbf{u}\cdot\mathbf{n} &= 0, \\ (\mathbb{S}\mathbf{n})_{\boldsymbol{\tau}} &= 0 \end{aligned} \tag{5}$$

$$-\mathbf{q}\cdot\mathbf{n} + L(\vartheta - \Theta_0) = 0. \tag{6}$$

We assume the fluid to be Newtonian, i.e. $\mathbb{S} = \mathbb{S}(\vartheta,\nabla\mathbf{u}) = \mu(\vartheta)(\nabla\mathbf{u} + \nabla\mathbf{u}^T - \frac{2}{3}\operatorname{div}\mathbf{u}\mathbb{I}) + \xi(\vartheta)\operatorname{div}\mathbf{u}\mathbb{I}$, with the pressure $p(\rho,\vartheta) \sim \rho\vartheta + \rho^\gamma$ and the heat flux $\mathbf{q}(\vartheta,\nabla\vartheta) = -\kappa(\vartheta)\nabla\vartheta$. We study existence of a solution to our problem (2)–(6) in dependence on γ, α and m, where $\mu(\vartheta)$, $\xi(\vartheta) \sim (1+\vartheta)^\alpha$, $\kappa(\vartheta) \sim (1+\vartheta)^m$.

Two-Phase Flows with Phase Transitions

Jan Prüss
Universität Halle, Germany

A thermodynamically consistent model for two-phase flows including phase transitions driven by temperature is introduced and analyzed. We briefly discuss the well-posedness of the model in an L_p-setting which is based on *maximal regularity*. The main part of the talk is devoted to the qualitative behavior of the generated local semiflow in the natural, nonlinear state manifold of the problem. The negative total entropy of the problem serves as a strict Ljapunov functional hence solutions which do not develop singularities are shown to converge to an equilibrium in the topology of the state manifold, as time goes to infinity. This result is based on the *generalized principle of linearized stability*.

Problems with p-structure: analysis and numerics

Michael Růžička
Univ. Freiburg, Czech Republic

The motion of generalized Newtonian fluids has attracted a huge research activity in the last 15 years. Motivated by this we will present some recent results concerning the existence of weak solutions for steady motions of generalized Newtonian fluids. Moreover, we will discuss results proving convergence rates for various problems with so called p-structure. In particular we will discuss Finite Element and Local Discontinuous Galerkin methods.

On the well-posedness of the free plasma-vacuum interface problem

Paolo Secchi

Brescia Univ., USA

We consider the free boundary problem for the plasma-vacuum interface in ideal compressible magnetohydrodynamics (MHD). In the plasma region the flow is governed by the usual compressible MHD equations, while in the vacuum region we consider the pre-Maxwell dynamics for the magnetic field. At the free-interface the total pressure is prescribed to be continuous and the magnetic field is tangent to the free boundary.

Problems of this kind appear in the mathematical modeling of plasma confinement by magnetic fields. In astrophysics, the plasma-vacuum interface problem can be used for modeling the motion of a star or the solar corona. In our talk we will discuss the well-posedness of the problem in anisotropic Sobolev spaces under a suitable stability condition satisfied at each point of the initial discontinuity. This is a joint work with Y. Trakhinin (Novosibirsk).

Recent trends in the mathematical modeling of blood coagulation

Adélia Sequeira
Technical Univ. Lisbon, Portogal

Blood coagulation is a remarkably complicated process going through several stages and culminating in a chemical cascade that involves a number of chemicals. The final target is the formation of a fibrin network entrapping all blood constituents in a gel structure (the clot). The clot evolution leads to a free boundary problem. A parallel much slower process (fibrinolysis) leads eventually to the clot dissolution.

The biological model currently in use is the so-called “cell-based model”, which has recently replaced the “three-pathway cascade model”. The development of biological theories on blood coagulation and bleeding disorders is in constant evolution and new discoveries suggest that even the cell-based model may need some correction.

In the recent literature on mathematical modeling of blood coagulation, two opposite trends have been observed: on one side a tendency towards “completeness” with an incredible number of pde’s describing the biochemistry in great detail (but sometimes ignoring platelets); on the other side a tendency to focus just on the role of platelets. Those ways of approaching the problem have their own advantages and drawbacks. The ‘complete models” fail in any case to consider elements of great importance that have been systematically ignored in the literature. The models considering just platelets can be used only for some very early stage of the process. A basic feature of any realistic coagulation model is the coupling between the biochemistry, the evolution of platelets population, and the flow of blood (in turn influenced by the growing clot). Thus blood rheology has a basic role. Blood rheology is known to be a very complicated subject and many different options have been offered. Nevertheless, the main point here is not which rheological model is preferable for blood, but the boundary conditions for blood flow. All models on blood coagulation use a no-slip condition.

In the present talk we introduce a mathematical model that includes blood slip at the vessel wall, emphasizing an extra supply of activated platelets to the clotting site. The expectations are that such contribution could be dominant, resulting in the acceleration of thrombin production and eventually of the whole clot progression. Such model will have the capacity to predict effects of specific perturbations in the hemostatic system that cannot be undertaken by laboratory tests. Numerical results based on the solution of the system of advection-reaction-diffusion equations coupled to the Navier-Stokes equations (or to a shear-thinning generalized Newtonian model) describing the blood flow, will be presented. Evolution of clot growth and the importance of the blood flow on its formation will be discussed and the concentration of coagulation factors will be investigated in the injury site of the vessel wall.

The behavior of L_3-norm of solutions to the Navier-Stokes equations as time approaches a possible blowup

Gregory Seregin
Oxford Univ., USA

We show that if T is blowup time of solution u to the Navier-Stokes equation then $\lim_{t\to T-0}\|u(\cdot,t)\|_{L_3}=\infty$.

On a thermodynamically consistent Stefan problem with variable surface energy

Gieri Simonett
Vanderbilt University, USA

A thermodynamically consistent two-phase Stefan problem with temperature-dependent surface tension and with or without kinetic undercooling is studied. It is shown that this problem generates a local semiflow on a well-defined state manifold. Moreover, stability and instability results of equilibrium configurations will be presented. It will be pointed out that surface heat capacity has a striking effect on the stability behavior of multiple equilibria. (Joint work with J. Prüss and M. Wilke).

Uniqueness of backward asymptotically almost periodic-in-time solutions to Navier-Stokes equations in unbounded domains

Yasushi Taniuchi
Shinshu Univ., Japan

This is a joint work with R. Farwig (TU Darmstadt). We present a uniqueness theorem for backward asymptotically almost periodic solutions to the incompressible Navier-Stokes equations in 3-dimensional unbounded domains. Thus far, uniqueness of such solutions to the Navier-Stokes equations in unbounded domain, roughly speaking, is known only for a small solution in $BC(-\infty,T;L^{3,\infty})$ within the class of solutions which have sufficiently small $L^\infty(L^{3,\infty})$-norm. In this talk, we show that a small backward asymptotically almost periodic solution in $BC(-\infty,T;L^{3,\infty}\cap L^{6,2})$ is unique within the class of all backward asymptotically almost periodic solutions in $BC(-\infty,T;L^{3,\infty}\cap L^{6,2})$. Here $L^{p,q}$ denotes the Lorentz space.

First we introduce the definitions of almost and backward asymptotically almost periodic functions with values in a Banach space B.

Definition. *(i) A function $f\in BUC(\mathbb{R};B)$ is called an almost periodic function in B on $\mathbb{R}$ if for all $\varepsilon>0$ there exists $L=L(\varepsilon)>0$ with the following property: For all $a\in\mathbb{R}$, there exists $\tau\in[a,a+L]$ such that*

$$\sup_{t\in\mathbb{R}}\|f(t+\tau)-f(t)\|_B\le\varepsilon.$$

Let us denote by $AP(\mathbb{R};B)$ the set of all almost periodic functions in B on $\mathbb{R}$.

(ii) Let $T\le\infty$. A function $f\in BUC((-\infty,T);B)$ is called a backward asymptotically almost periodic function in B on $(-\infty,T)$ if there exist $f_1,f_2\in BUC((-\infty,T);B)$ such that

$$f=f_1+f_2 \text{ on } (-\infty,T),\quad f_1\in AP(\mathbb{R};B),\quad f_2\in BUC((-\infty,T);B)$$
$$\text{with } \lim_{t\to-\infty}\|f_2(t)\|_B=0.$$

Let us denote by $BAAP((-\infty,T);B)$ the set of all backward asymptotically almost periodic functions in B on $(-\infty,T)$.

Now our main result reads as follows:

Main theorem. *Let Ω be an exterior domain with $\partial\Omega\in C^\infty$, $\mathbb{R}^3$ or $\mathbb{R}^3_+$. Then, there exists a constant $\delta=\delta(\Omega)>0$ such that if $T<\infty$, $u,v\in BAAP((-\infty,T);L^{3,\infty})$ are mild solutions to (N-S) on $(-\infty,T)$ for the same external force f,*

$$u,v\in L^2_{uloc}((-\infty,T);L^{6,2}(\Omega)), \tag{7}$$

and if

$$\limsup_{t\to-\infty}\|u(t)\|_{L^{3,\infty}}<\delta, \tag{8}$$

then $u=v$ on $(-\infty,T)$.

The Three-Dimensional Euler Equations: Recent Advances

Edriss S. Titi
Weizmann Institute & University of California, USA

A basic example of shear flow was introduced by DiPerna and Majda to study the weak limit of oscillatory solutions of the Euler equations of incompressible ideal fluids. In particular, they proved by means of this example that weak limit of solutions of Euler equations may, in some cases, fail to be a solution of Euler equations. We use this shear flow example to provide non-generic, yet nontrivial, examples concerning the immediate loss of smoothness and ill-posedness of solutions of the three-dimensional Euler equations, for initial data that do not belong to $C^{1,\alpha}$. Moreover, we show by means of this shear flow example the existence of weak solutions for the three-dimensional Euler equations with vorticity that is having a nontrivial density concentrated on non-smooth surface. This is very different from what has been proven for the two-dimensional Kelvin-Helmholtz problem where a minimal regularity implies the real analyticity of the interface. Eventually, we use this shear flow to provide explicit examples of non-regular solutions of the three-dimensional Euler equations that conserve the energy, an issue which is related to the Onsager conjecture. In addition, we will use this shear flow to provide a nontrivial example for the use of vanishing viscosity limit, of the Navier-Stokes solutions, as a selection principle for uniqueness of weak solutions of the 3D Euler equations.

This is a joint work with Claude Bardos.

Mathematical justification and error estimate for the penalty method of the Navier-Stokes equations

Norikazu Yamaguchi
Univ. of Toyama, Japan

The penalty method introduced by Temam is widely used in numerical computation of the Navier-Stokes equations. By the penalty method, the solenoidal condition of the velocity is approximated by $\operatorname{div} u^\varepsilon = -\varepsilon p^\varepsilon$, where u^ε and p^ε are velocity and pressure, respectively; $\varepsilon > 0$ is assumed to be small parameter. Substituting $p^\varepsilon = -\operatorname{div} u^\varepsilon/\varepsilon$ into the equations of motion, we have an approxmation of the Navier-Stokes equations. In such an approxiamtion, letting $\varepsilon \to +0$, the solenoidal condition is recovered. Therefore it seems that the penalty method works well. However, such an observation is just a formal one. We need some rigorous justification.

In this talk, I will talk about a rigorous justification of the penalty method for the Cauchy problem of the Navier-Stokes equations. In particular, I will show that a solution of penalized Navier-Stokes equations converges to the solution of original problem. Ingredients of proof are semigroup theory and the Helmholtz decomposition.

POSTER SECTION

On the uniqueness of the Stokes flow in half space with singularity at time zero

Ken Abe
The University of Tokyo, Japan

We present a uniqueness result for the Stokes equations in a half space where velocity is merely bounded. The problem arises from an L^∞-bound of the nonlinear Navier-Stokes equations. We extend the uniqueness result given by Solonnikov (2003) to the case velocity having a singularity at time zero. Because of the presence of non-decaying Poiseuille flows a pressure decay condition is necessary to the uniqueness. We also present an application to L^∞-bounds for solutions to the Navier-Stokes equations.

On free boundary value problems related to the spin coating system

Lorenz Von Below
Waseda Univ./TU Darmstadt, Japan/Germany

Spin coating is a method to cover a substrate with a thin layer which is widely applied in microelectronics, e. g. in the production of wafers. Denk, Geissert, Hieber, Saal, and Sawada [1] studied a model for the spin coating process. The model they proposed is essentially a free boundary value problem for the Navier-Stokes equations in a domain $\Omega(t)$ close to an infinite layer with fixed lower and free upper boundary including surface tension and rotational effects.

We present results about existence and uniqueness of solutions to linear problems arising in the study of the spin coating system and related free boundary value problems with and without surface tension. Our results rely on a careful analysis of explicit solution formulae by means of Fourier analytic techniques.

References

[1] Robert Denk, Matthias Geissert, Matthias Hieber, Jürgen Saal, and Okihiro Sawada. The spin-coating process: Analysis of the free boundary value problem. *Communications in Partial Differential Equations*, 36(7):1145–1192, 2011.

Asymptotic behavior of solutions to the compressible Navier-Stokes equation around a time-periodic parallel flow

Jan Brezina
Kyushu Univ., Japan

Under appropriate smallness conditions on Reynolds and Mach numbers we show the global in time existence of strong solutions to the compressible Navier-Stokes equation around time-periodic parallel flows in R^n, $n \geq 2$. Furthermore, we study the asymptotic behavior of these solutions and prove that the cases $n = 2$ and $n \geq 3$ are considerably different.

A numerical oscillation problem of particle method MPS

Motofumi Hattori
Kanagawa Institute of Technology, Japan

We simulate the deformation of liquid based on the incompressible Navier-Stokes equation which is described by the Lagrangian material coordinate. Let $u(t,\xi) = (u_x(t,\xi), u_y(t,\xi), u_z(t,\xi))$ be the position of the liquid's particle $\xi = (\xi_x, \xi_y, \xi_z)$ at time $t \geq 0$. Then $u(0,\xi) = \xi$. Let $v(t,\xi) = (v_x(t,\xi), v_y(t,\xi), v_z(t,\xi))$ be the velocity of the particle ξ at time $t \geq 0$. Let $\rho(t,\xi)$ be the mass density around the particle ξ at time $t \geq 0$. Let $p(t,\xi)$ be the pressure around the particle ξ at time $t \geq 0$.

Let Δt be a sampling time. The position u, the velocity v, and the pressure p are computed at time $t = \tau\,\Delta t$
($\tau = 0,1,2,\cdots$). Let $U[\tau](\xi)$ be an approximate value for $u(\tau\,\Delta t,\ \xi)$, let $V[\tau](\xi)$ be an approximate value for $v(\tau\,\Delta t,\ \xi)$, let $P[\tau](\xi)$ be an approximate value for $p(\tau\,\Delta t,\ \xi)$, and let $\mathrm{Rho}[\tau](\xi)$ be an approximate value for $\rho(\tau\,\Delta t,\ \xi)$.

The position $U[\tau]$, the velocity $V[\tau]$, the pressure $P[\tau]$ and the mass density $\mathrm{Rho}[\tau]$ should satisfy

$$\frac{V[\tau+1]-V[\tau]}{\Delta t} = \frac{\mu}{\rho_0}\sum_{i=x,y,z}\frac{\partial^2 V[\tau]}{\partial U_i[\tau]^2} - \frac{1}{\rho_0}\frac{\partial P[\tau+1]}{\partial U[\tau+1]} + g \tag{9}$$

$$\frac{U[\tau+1]-U[\tau]}{\Delta t} = V[\tau+1] \qquad \mathrm{Rho}[\tau] = \rho_0 \tag{10}$$

For these goal equations (9) and (10), the variables $U[\tau+1]$, $V[\tau+1]$, $P[\tau+1]$, and $\mathrm{Rho}[\tau+1]$ at next time $\tau+1$ are computed from the variables $U[\tau]$, $V[\tau]$, $P[\tau]$, and $\mathrm{Rho}[\tau]$ at present time τ , as follows.

The temporal velocity V^* and the temporal position U^* are computed only by the viscosity term and the gravity term ignoring the pressure term as

$$\frac{V^*-V[\tau]}{\Delta t} = \frac{\mu}{\rho_0}\sum_{i=x,y,z}\frac{\partial^2 V[\tau]}{\partial U_i[\tau]^2} + g,\ \frac{U^*-U[\tau]}{\Delta t} = V^*,\ \mathrm{Rho}^*(\xi) = \frac{\rho_0}{\det\left(\frac{\partial U^*(\xi)}{\partial \xi}\right)} \tag{11}$$

Comparing the discrete time Navier-Stokes equation (9), in order to recover the effect of pressure $P[\tau+1]$ (unknown) to the equation (11), we consider the modifiers V' , U' and the pressure $P[\tau+1]$ as

$$V[\tau+1] \;=\; V^*+V',\ U[\tau+1] = U^*+U',\ \frac{V'}{\Delta t} = \frac{-1}{\rho_0}\,\frac{\partial P[\tau+1]}{\partial U[\tau+1]},\ \frac{U'}{\Delta t} = V' \tag{12}$$

By adding V^* and V', we obtain the equation (9). Taking the divergence of the equation (12),

$$\frac{-1}{\rho_0}\sum_{i=x,y,z}\frac{\partial^2 P[\tau+1]}{\partial U_i[\tau+1]^2} = \frac{1}{\Delta t}\sum_{i=x,y,z}\frac{\partial V_i'}{\partial U_i[\tau+1]} \tag{13}$$

The incompressibility leads to

$$0 = \sum_{i=x,y,z} \frac{\partial V_i[\tau+1]}{\partial U_i[\tau+1]} = \sum_{i=x,y,z} \frac{\partial V_i^*}{\partial U_i^*} + \sum_{i=x,y,z} \frac{\partial V_i'}{\partial U_i[\tau+1]} \tag{14}$$

$$\sum_{i=x,y,z} \frac{\partial V_i'}{\partial U_i[\tau+1]} = (-1) \sum_{i=x,y,z} \frac{\partial V_i^*}{\partial U_i^*} = \frac{1}{\mathrm{Rho}^*} \; \frac{\mathrm{Rho}^* - \rho_0}{\Delta t} \tag{15}$$

with the equation of continuity

$$0 = \frac{\mathrm{Rho}^* - \rho_0}{\Delta t} + \mathrm{Rho}^* \sum_{i=x,y,z} \frac{\partial V_i^*}{\partial U_i^*}$$

The equation (13) and the equation (15) lead to the following pressure Poisson equation

$$\sum_{i=x,y,z} \frac{\partial^2 P[\tau+1]}{\partial U_i[\tau+1]^2} = \frac{\rho_0}{\mathrm{Rho}^*} \; \frac{\rho_0 - \mathrm{Rho}^*}{(\Delta t)^2} \tag{16}$$

We compute the pressure $P[\tau+1]$ by solving this pressure Poisson equation (16) for the estimated position

$$\mathbf{U}[\tau+1] = U[\tau] + V[\tau] \times \Delta t$$

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On a strong solution of the Navier-Stokes equations under slip or leak boundary conditions of friction type

Takahito Kashiwabara
Univ. of Tokyo, Japan

We are concerned with the incompressible Navier-Stokes equation

$$\begin{cases} u' + (u\cdot\nabla)u - \nu\Delta u + \nabla p = f & \text{in } \Omega, \\ \operatorname{div} u = 0 & \text{in } \Omega, \\ u|_{t=0} = u_0 & \text{in } \Omega, \end{cases}$$

where $\Omega \subset \mathbb{R}^d$ $(d = 2,3)$ is a bounded smooth domain. Consider one of the following two boundary conditions:

$$u_n = 0, \quad |\sigma_\tau| \leq g, \quad \sigma_\tau \cdot u_\tau + g|u_\tau| = 0,$$
$$u_\tau = 0, \quad |\sigma_n| \leq g, \quad \sigma_n u_n + g|u_n| = 0,$$

where u_n and σ_n (resp. u_τ and σ_τ) denote the normal (resp. tangential) component of the velocity and stress vector respectively. g is a given threshold of the tangential or normal stress. They are called the slip or leak boundary conditions of friction type (SBCF/LBCF).

Although the well-posedness for the stationary problem with SBCF/LBCF is already known, that for the non-stationary case was not fully covered. In this study, we provide existence and uniqueness results to SBCF/LBCF problems, which will be of use for starting numerical analysis of the problems.

Global weak solutions for the interaction of a viscous incompressible fluid with a Koiter shell

Daniel Lengeler
Regensburg University, Germany

I will present a result concerning the interaction of an incompressible, generalized Newtonian fluid with a linearly elastic Koiter shell whose motion is restricted to transverse displacements. The middle surface of the shell constitutes the mathematical boundary of the three-dimensional fluid domain. The main result is the existence of global-in-time weak solutions in the case that the viscous stress tensor possesses a p-structure with $p > 6/5$.

Zhukovskii's Conjecture for the Motion of a Rigid Body Filled with a Viscous Fluid

Giusy Mazzone
Pittsburgh Univ., USA

We consider a rigid body with a cavity completely filled by a Newtonian viscous fluid and we study the existence of weak and strong solutions for the coupled system formed by the Navier-Stokes equations and the equations of the balance of the total angular momentum of the system fluid-rigid body in absence of total body forces acting on the fluid and external forces and torques on the rigid body. The aim of our investigation is to give a complete description of the asymptotic behavior of the coupled system fluid-rigid body. In particular, we prove a conjecture stated by Zhukovskii, namely that the system possesses a global attractor in the class of solutions having finite energy, which is characterized by zero relative velocity and constant angular velocity directed along one of the principal axes of inertia of the whole system fluid-rigid body. In other words, the liquid goes to rest with respect to the rigid body and the motion of the whole system approaches to a constant rigid rotation about one of the principal axes of the system.

On the sectorial $\mathscr{R}$-boundedness of the Stokes operator for the compressible viscous fluid flow in a general domain

Miho Murata
Waseda Univ., Japan

We consider the linearized problem describing motion of the compressible viscous fluid flow in a general domain with slip boundary condition. The general domain is uniform $W_r^{3-1/r}$ domain and slip boundary condition is consist of first order derivative term and non-homogeneous data. Our purpose is the generation of analytic semigroup and the maximal L_p-L_q regularity. In order to show these purpose, $\mathscr{R}$-boundedness is key idea. Since we consider non-homogeneous boundary condition containing first order derivative term, it is necessary to prove existence of solution operator from detail data as ∇h and $\lambda^{1/2}h$ to solution and $\mathscr{R}$-boundedness for this operator, where h is boundary data. By this idea, we can show not only resolvent estimate but maximal L_p-L_q regularity.

Uniqueness of steady Navier-Stokes flows in exterior domains

Tomoyuki Nakatsuka
Nagoya Univ., Japan

We consider the uniqueness of stationary solutions to the Navier-Stokes equation in 3-dimensional exterior domains within the class $u \in L_{3,\infty}$ with $\nabla u \in L_{3/2,\infty}$, where $L_{3,\infty}$ and $L_{3/2,\infty}$ are the Lorentz spaces. It is shown that if solutions u and v satisfy the conditions that u is small in $L_{3,\infty}$ and $v \in L_3 + L_\infty$, then $u = v$. The proof relies upon the regularity theory for the perturbed Stokes equation.

Nonlinear stability of plasma boundary layers with fluid-boundary interaction

Masashi Ohnawa
Waseda Univ., Japan

This study is concerned with the analysis of the stability of a boundary layer, called sheath, which appears over materials in contact with plasma. Its behavior is described by the Euler-Poisson equations over a one-dimensional half space and the sheath is understood as a monotone stationary solution. In our model, both ions and electrons accumulate at the boundary due to the flux from the inner region. This leads to the temporal change of electrostatic potential gradient at the boundary, which affects the potential over the whole space through the Poisson equation. Ions in the inner region are then accelerated by this potential gradient, determining the flux to the boundary. Our goal is to prove the asymptotic stability of the stationary solution under this fluid-structure interaction setting.

Numerical analysis of the flow around a circular cylinder

Issei Oikawa
Waseda Univ., Japan

In this paper, we show numerical solutions of the Oseen equations around a circular cylinder. The numerical method we adopted is the conforming finite element method (FEM) with artificial boundaries. The advantages and side effects of stabilization by the streamline-upwind/Petrov-Galerkin (SUPG) and pressure-stabilizing Petrov-Galerkin (PSPG) methods are presented. We also examine the validity of iterative solvers, for example, the biconjugate gradient stabilized (BiCGSTAB) and generalized minimal residual (GMRES) methods.

On the maximal regularity of the Stokes problem with the Neumann-Robin boundary condition in an infinite layer

Hirokazu Saito
Waseda Univ., Japan

We would like to consider the maximal regularity of the Stokes problem with the Neumann-Robin-type boundary condition in an infinite layer in the L_p-time and L_q-space setting. The Stokes problem is a reduced linearized problem of the spin coating process, which is a free boundary value problem for viscous incompressible fluid. In free boundary value problems, the equations turn into quasilinear when we change the time dependent domain into a fixed domain. Therefore, we need the maximal regularity in order to deal with free boundary value problems. As a first step, we show the maximal regularity of the Stokes problem.

Asymptotic behavior of solutions to a shallow water model

Masahiro Suzuki
Tokyo Institute of Technology, Japan

We analyze the asymptotic behavior of the time global solution to the initial boundary value problem for a shallow water model. If we adopt a boundary condition that the flux of water is constant, then it is proved that there exists a one-parameter family of the stationary solutions. This fact causes a delicate issue of determining the stationary solution, which should be a time asymptotic state of the time global solution. We show the unique existence and the time asymptotic stability of the stationary solution, which satisfies the zero mass condition, with adopting the constant-flux boundary condition.

Dispersive estimates for the Navier-Stokes equations in the rotational framework

Ryo Takada
Kyoto University, Japan

The main interest of this poster is to derive an improved dispersion effect of the Coriolis force, arising in the incompressible Navier–Stokes equations in the rotational framework. Such a dispersion phenomenon is closely related to the dispersive estimate for the operator $e^{\pm i\Omega t \frac{D_3}{|D|}}$, where $\Omega \in \mathbb{R}$ represents the speed of rotation around the vertical unit vector $e_3 = (0,0,1)$. We prove the two–dimensional dispersive estimates for the propagator $e^{\pm i\Omega t \frac{D_3}{|D|}}$. As applications to the Navier–Stokes equations with the Coriolis force, we prove the unique existence of global in time solutions for large initial velocities, and the unique existence of time periodic solutions for large external forces provided the speed of rotation is sufficiently high.

This is a joint work with Professor Youngwoo Koh (Seoul National Univ.) and Professor Sanghyuk Lee (Seoul National Univ.).

On a diffuse interface model for non-Newtonian two phase flows with matched densities

Yutaka Terasawa
The University of Tokyo, Japan

We consider a diffuse interface model for power-law fluidswith mathced densities. We construct weak solutions of the system with a certain range of the powers associated with power-law fluid equations part. For the construction of the solutions, we consider an approximate system and pass its solution to the limit, using an adaptation of the Lipshitz truncation method, which was used for the construction of weak solutions of the power-law fluid equations with low powers in Diening-Ruzicka-Wolf ('10). This poster is based on a joint work with Helmut Abels (Regensburg) and Lars Diening (Munich).