Last update: December 1, 2022

International Workshop on Multiphase Flows: Analysis, Modelling and Numerics

Dates: December 5-9, 2022

Venue: Waseda University (Dec. 5-7, 9), RIHGA Royal Hotel Tokyo (Dec. 8)

Timetable

December 5 (Mon.)

10:10 – 10:20 Opening

10:20 – 11:10 Giovanni P. Galdi (University of Pittsburgh)

"Mathematical Analysis of Flow-Induced Oscillations of a Spring-Mounted Body in a Navier-Stokes Liquid"

11:10 – 11:30 Coffee Break

11:30 – 12:20 Toshiaki Hishida (Nagoya University)

"Stability of time-dependent motions for fluid-rigid ball interaction"

12:20 – 14:00 Lunch

14:00 – 14:50 Yasushi Taniuchi (Shinshu University)

"On uniqueness of mild $L^{3,\infty}$-solutions on the whole time axis to the Navier-Stokes equations in unbounded domains"

15:00 – 15:50 Shinya Nishibata (Tokyo Institute of Technology)

"Asymptotic stability of spherically symmetric stationary solutions for the compressible Navier-Stokes equation"

15:50 – 16:10 Coffee Break

16:10 – 17:00 Priyanjana M. N. Dharmawardane (Wayamba University of Sri Lanka)

"Global existence of solutions for the systems of thermoviscoelasticity"

Birkhäuser Distinguished Lecture on Mathematical Fluid Mechanics

17:30– 18:30 Yoshihiro Shibata (Waseda University)

"The L_p-L_q maximal regularity and free boundary problem for the Navier-Stokes equations"

December 6 (Tue.)

9:40 – 10:30 Matthias Hieber (TU Darmstadt)

"Interaction of Deterministic and Stochastic Forces with the Anisotropic Navier-Stokes and Primitive Equations"

10:30 – 10:50 Coffee Break

10:50 – 11:40 Gieri Simonett (Vanderbilt University)

"Fluid flow on surfaces"

11:50 – 12:40 Thomas Eiter (Weierstrass Institute for Applied Analysis and Stochastics)

"Existence of time-periodic flows in domains with oscillating boundaries"

12:40 – 14:00 Lunch

14:00 – 14:50 Kenta Oishi (Waseda University)

"On the global well-posedness and decay of a free boundary problem of the Navier–Stokes equation in two-dimensional half space"

15:00 – 15:50 Hirokazu Saito (The University of Electro-Communications)

"On decay properties of the Stokes semigroup for two-phase flows"

15:50 – 16:10 Coffee Break

16:10 – 16:40 Jumpei Inoue (Waseda University)

"Maximize the ratio of biomass to resources in a class of diffusive logistic equations"

16:50 – 17:20 Tadashi Udagawa (Waseda University)

"Global solutions of the sinh-Gordon equation and the Iwasawa factorization for loop groups"

17:30 – 18:00 Taiki Takeuchi (Waseda University)

"Inviscid limits for the Keller-Segel-Navier-Stokes system of parabolic-elliptic type"

December 7 (Wed.)

9:40 – 10:30 Takayuki Kubo (Ochanomizu University)

"Existence of weak solution to the nonstationary Navier-Stokes equations approximated by pressure stabilization method"

10:30 – 10:50 Coffee Break

10:50 – 11:40 Ryo Takada (The University of Tokyo)

"Global solutions for the incompressible rotating MHD equations in the scaling critical Sobolev space"

11:50 – 12:40 Ryosuke Nakasato (Waseda University)

"On the asymptotic stability for the quantum Hall-MHD via $\widehat{L^p}$ energy methods"

12:40 – 14:00 Lunch

14:00 – 14:50 Mitsuo Higaki (Kobe University)

"Planar Navier–Stokes flows with flux in exterior domains"

15:00 – 15:50 Keiichi Watanabe (Waseda University)

"Large time behavior of solutions to the Navier-Stokes equations in exterior Lipschitz domains"

15:50 – 16:10 Coffee Break

16:10 – 17:00 Matthias Köhne (Heinrich-Heine-Universität Düsseldorf)

"Contact Line Dynamics I - Modeling and Regularity of Solutions"

17:30 – 18:30 Jürgen Saal (Heinrich-Heine-Universität Düsseldorf)

"Contact Line Dynamics II - Maximal Regularity in the Weak Setting"

December 8 (Thu.)

9:30 – 10:20 Xin Zhang (Tongji University)

"Classical solution for the compressible flow with free surface in three dimensional exterior domain"

10:30 – 11:20 Paolo Maremonti (Università degli Studi della Campania "Luigi Vanvitelli")

"Existence of solutions to the Navier-Stokes Cauchy problem in the L^3 setting"

11:20 – 11:35 Coffee Break

11:35 – 12:25 Takayuki Kobayashi (Osaka University)

"Global well-posedness of the compressible Navier-Stokes-Korteweg system under critical condition"

12:25 – 13:45 Lunch

13:45 – 14:35 Shuichi Kawashima (Waseda University)

"Dissipative structure for the system in electro-magneto-hydrodynamics"

14:45 – 15:35 Reinhard Racke (University of Konstanz)

"Stability of relaxed multi-d compressible Navier-Stokes equations"

15:35 – 15:50 Coffee Break

15:50 – 16:40 Takayoshi Ogawa (Tohoku University)

"Free surface problem of the incompressible Navier-Stokes equations in a scaling critical space"

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December 9 (Fri.)

9:40 – 10:30 Tohru Ozawa (Waseda University)

"Method of Modified Energy"

10:30 – 10:50 Coffee Break

10:50 – 11:40 Tsukasa Iwabuchi (Tohoku University)

"A localized maximum principle and an application to the critical SQG on bounded domain"

11:50 – 12:40 Vladimir Georgiev (University of Pisa)

"A new class of small initial data which may shift the lifespan estimates for the classical damped wave equations"

12:40 – 12:50 Closing

Organized by

Yoshihiro Shibata, Takayuki Kubo, Hirokazu Saito, Keiichi Watanabe, Kenta Oishi

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Monday, December 5th, 2022

Mathematical Analysis of Flow-Induced Oscillations of a Spring-Mounted Body in a Navier-Stokes Liquid

Giovanni P. Galdi
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We study the motion of a rigid body $\mathscr{B}$ subject to an undamped elastic restoring force, in the stream of a viscous liquid $\mathscr{L}$. The motion of the coupled system $\mathscr{B}$-$\mathscr{L} \equiv \mathscr{S}$ is driven by a uniform flow of $\mathscr{L}$ at spatial infinity, characterized by a given, constant dimensionless velocity $\lambda \boldsymbol{e}_1$, $\lambda > 0$. We show that as long as $\lambda \in (0, \lambda_c)$, with λ_c a distinct positive number, there is a uniquely determined time-independent state of $\mathscr{S}$ where $\mathscr{B}$ is in a (locally) stable equilibrium and the flow of $\mathscr{L}$ is steady. Moreover, in that range of λ, no oscillatory flow may occur. Successively we prove that if certain suitable spectral properties of the relevant linearized operator are met, there exists a $\lambda_0 > \lambda_c > 0$ where an oscillatory regime for $\mathscr{S}$ sets in. More precisely, a bifurcating time-periodic branch stems out of the time-independent solution. The significant feature of this result is that *no* restriction is imposed on the frequency, ω, of the bifurcating solution, which may thus coincide with the natural structural frequency, ω_{n}, of $\mathscr{B}$, or any multiple of it. This implies that a dramatic structural failure cannot take place due to resonance effects. However, our analysis also shows that when ω becomes sufficiently close to ω_{n} the amplitude of oscillations can become very large in the limit when the density of $\mathscr{L}$ becomes negligible compared to that of $\mathscr{B}$.

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Stability of time-dependent motions for fluid-rigid ball interaction

Toshiaki Hishida
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We aim at stability of time-dependent motions, such as time-periodic ones, of a rigid body in a viscous fluid filling the whole $\mathbb{R}^3$. The fluid motion obeys the incompressible Navier-Stokes system, whereas the motion of the body is governed by the balance of linear and angular momentum. Both motions are affected by each other at the boundary. Assuming that the rigid body is a ball, we adopt a monolithic approach to deduce L^q-L^r decay estimates of solutions to a non-autonomous linearized system by adaptation from the method developed by the speaker on the similar estimates, however, for the exterior problem without interaction with a moving obstacle. We then apply those estimates to the full nonlinear initial-value problem to find temporal decay properties of the disturbance. To our knowledge, the only work on the issue above in 3D is a recent paper by Ervedoza, Maity and Tucsnak, in which nonlinear stability of the rest state is established when the structure is a rigid ball. Although the shape of the body is still not allowed to be general, the present contribution is the first attempt at analysis of the large time behavior of solutions around nontrivial basic states, that can be time-dependent, for fluid-structure interaction problem and provides us with a stability theorem which is indeed new even for steady motions with wake.

On uniqueness of mild $L^{3,\infty}$-solutions on the whole time axis to the Navier-Stokes equations in unbounded domains

Yasushi Taniuchi
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The motion of a viscous incompressible fluid in 3-dimensional domains Ω is governed by the Navier-Stokes equations:

$$\text{(N-S)} \begin{cases} \partial_t u - \Delta u + u \cdot \nabla u + \nabla p = f, & t \in (-\infty, \infty), x \in \Omega, \\ \nabla \cdot u = 0, & t \in (-\infty, \infty), \quad x \in \Omega, \\ u|_{\partial\Omega} = 0, \end{cases}$$

where $u = (u^1(x,t), u^2(x,t), u^3(x,t))$ and $p = p(x,t)$ denote the velocity vector and the pressure, respectively, of the fluid at the point $(x,t) \in \Omega \times \mathbb{R}$. Here f is a given external force. In this talk, we consider the uniqueness of bounded mild $L^{3,\infty}$-solutions to (N-S) on the whole time axis $(-\infty, \infty)$ (or half-line $(-\infty, T)$) in unbounded domains Ω. Here, $L^{3,\infty}$ denotes the weak L^3 space. Typical examples of such solutions are stationary, periodic-in-time and almost periodic-in-time solutions. It is known that a small solution in $BC(\mathbb{R}; L^{3,\infty})$ is unique within the class of solutions which have sufficiently small $L^\infty(\mathbb{R}; L^{3,\infty})$-norm; i.e., if two solutions u and v exist for the same force f, *both* u and v are small, then the two solutions coincide. There is another type of uniqueness theorem. If two solutions u and v exist for the same force f, u is small and if v has a precompact range $\mathcal{R}(v) := \{v(t); -\infty < t < T\}$ in $L^{3,\infty}$, then the two solutions coincide. Since almost periodic-in-time solutions have precompact range, this uniqueness theorem is applicable to almost periodic-in-time solutions. On the other hand, there exist many solutions which do not have precompact range. In this talk, instead of the precompact range condition, by assuming some decay property of v with respect to the spatial variable x, we give a modified version of the above-mentioned uniqueness theorem.

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Asymptotic stability of spherically symmetric stationary solutions for the compressible Navier-Stokes equation

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In the present talk, we discuss an asymptotic behavior of a spherically symmetric solution on the exterior domain of an unit ball for the compressible Navier-Stokes equation, describing a motion of viscous barotropic gas. Especially we study outflow problem, that is, the fluid blows out a through boundary. Precisely we obtain the property of the stationary solution and the convergence rate as the spatial variable tends to infinity. Then we show the time global existence of the solution and it converges to the stationary solution as time tends to infinity.

Global existence of solutions for the systems of thermoviscoelasticity

Priyanjana M. N. Dharmawardane

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This talk is based on the analysis of an n-dimensional systems of thermoviscoelasticity. In this model, motion of the thermoviscoelastic materials is described by the hyperbolic - parabolic systems which couple the nonlinear viscoelastic systems and the total energy balance equation. Here, the nonlinear viscoelastic systems consist of dissipation terms, namely, the memory term and the friction term. With careful use of the standard energy method developed by A. Matsumura and the estimates, related to memory term, derived by Dharmawardane, Rivera, Nakamura and Kawashima, especially obtaining estimates for the basic energy and for the dissipative terms, we obtain the global existence and asymptotic decay of solutions for $n \geq 1$, provided that the initial data are smooth and sufficiently small in L^2-Sobolev space.

[*This is a joint research work with Prof. Shuichi Kawashima (Waseda University) and Prof. Yoshihiro Shibata (Waseda University).*]

[*The speaker would like to extend his sincere gratitude to Waseda University for providing facilities to complete this research work.*]

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The L_p-L_q maximal regularity and free boundary problem for the Navier-Stokes equations

Yoshihiro Shibata*

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First, I will talk about the $\mathcal{R}$ solver method created by myself to prove the maximal regularity for the initial- boundary problem with non-homogeneous boundary date. By using this method, I proved the L_p in time and L_q in space maximal regularity theorem for the Stokes equations with free bounanry conditions. The idea of $\mathcal{R}$ solver is based on Weis operator valued Fourier multiplier theorem. As an application, I will talk about the local and global wellposedness of free bounary problem of the Navier-Stokes equations.

*This talk is given as the 2022 Birkhäuser Distinguished Lectures in Mathematical Fluid Mechanics, sponsored and organized by Birkhäuser on behalf of the Editorial Board of the *Journal of Mathematical Fluid Mechanics*. This talk is recorded and will be uploaded to the Birkhäuser's YouTube channel.

Tuesday, December 6th, 2022

Interaction of Deterministic and Stochastic Forces with the Anisotropic Navier-Stokes and Primitive Equations

Matthias Hieber

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In this talk we deduce the primitive equations subject to transport noise and turbulent pressure from the anisotropic Navier-Stokes equations and show that this set of equations admits a unique, strong, global solution under reasonable assumptions on the noise. We also consider related stochastic boundary value problems and show that they admit a unique, local pathwise solution in critical spaces, however, within an anisotropic $L^q - L^p$-setting of negative order. Finally, we consider the coupling of these equations with a viscous-plastic sea ice model and study its well-posedness. This is joint work with A. Agresti, T. Binz, F. Brandt, A. Hussein and M. Saal.

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Fluid flow on surfaces

Gieri Simonett

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I will consider the motion of an incompressible viscous fluid on compact surfaces without boundary. Local in time well-posedness is established in the framework of L_p-L_q maximal regularity for initial values in critical spaces. It will be shown that the set of equilibria consists exactly of the Killing vector fields. Each equilibrium is stable and any solution starting close to an equilibrium converges at an exponential rate to a (possibly different) equilibrium. In case the surface is two-dimensional, it will be shown that any solution with divergence free initial value in L_2 exists globally and converges to an equilibrium.

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Existence of time-periodic flows in domains with oscillating boundaries

Thomas Eiter

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We consider the flow of an incompressible viscous fluid inside a domain with a periodically moving boundary. The problem is reformulated as a time-periodic quasilinear problem in a domain with fixed boundary, and time-periodic maximal L^p-regularity for the linearized problem is derived from the $\mathcal{R}$-boundedness of the associated resolvent problems. For a bounded domain, existence of solutions to the original problem follows by a fixed-point argument, but for an exterior domain, the L^p theory is not sufficient for this fixed-point approach. Instead, one can use a framework that combines the time-periodic maximal regularity with pointwise decay estimates derived from the associated time-periodic fundamental solutions.

On the global well-posedness and decay of a free boundary problem of the Navier-Stokes equation in two-dimensional half space

Kenta Oishi

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We establish the global well-posedness and some decay properties for a free boundary problem of the incompressible Navier-Stokes equations in $\mathbb{R}^N_+$ with $N \geq 2$. Our preceding work [1] could not handle the case $N = 2$ because, for $N = 2$, the decay of the solution to the free boundary problem is too slow to control the nonliear term on the boundary. We overcome this difficulty owing to the trace estimate $\|f(x', 0)\|_{L_q(\mathbb{R}^{N-1})} \leq \|f\|^{1-1/q}_{L_q(\mathbb{R}^N_+)} \|\nabla f\|^{1/q}_{L_q(\mathbb{R}^N_+)}$, where $x' = (x_1, \cdots, x_{N-1})$.

References

[1] K. Oishi, Y. Shibata, On the global well-posedness and decay for a free boundary problem of the Navier-Stokes equation in unbounded domains, Mathematics, Vol. 10 (2022), No. 5, 774.

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On decay properties of the Stokes semigroup for two-phase flows

Hirokazu Saito

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In this talk, we consider two-phase Stokes equations with a sharp interface arsing from the study of the motion of two immiscible, incompressible, viscous fluids, fluid$_+$ and fluid$_-$, in the N-dimensional Euclidean space $\mathbf{R}^N$ for $N \geq 2$. The fluid$_+$ and fluid$_-$ occupy $\mathbf{R}^N_+$ and $\mathbf{R}^N_-$, respectively, where

$$\mathbf{R}^N_\pm = \{(x', x_N) : x' = (x_1, \ldots, x_{N-1}) \in \mathbf{R}^{N-1}, \pm x_N > 0\},$$

and the interface of the two fluids is given by

$$\mathbf{R}^N_0 = \{x' = (x_1, \ldots, x_{N-1}) \in \mathbf{R}^{N-1}, x_N = 0\}.$$

Our model includes surface tension on the interface and is considered in the presence of a uniform gravitational field acting vertically downward. Let $\rho_\pm$ be positive constants describing the densities of fluid$_\pm$. The aim of this talk is to show large time decay of the Stokes semigroup associated with the two-phase Stokes equations under the condition that $\rho_- \geq \rho_+$. We see that the decay rate in the case $\rho_- > \rho_+$ is different from one in the case $\rho_- = \rho_+$, and also asymptotic expansions of zeros of a boundary symbol give us polynomial decay rates which are similar to the semigroup generated by the fractional Laplacian.

Maximize the ratio of biomass to resources in a class of diffusive logistic equations

Jumpei Inoue

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In this talk, we study the stationary problem of a diffusive logistic equation with the Neumann boundary condition. In particular, we consider the problem to maximize the ratio of the total masses of species to that of resources. According to the previous research, the supremum of the ratio is equal to 3 in the one-dimension. We first show some detailed profiles for the solutions corresponding to the maximizing sequence in the one-dimension. We next claim that, in the high-dimensions, the supremum of the ratio equals to infinity. Moreover, we prove that the same supremum of the ratio holds with the Dirichlet boundary conditions.

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Global solutions of the sinh-Gordon equation and the Iwasawa factorization for loop groups

Tadashi Udagawa

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In this talk, we solve the harmonic map partial differential equation by using the DPW method and the Riemann-Hilbert method. The DPW method (the generalized Weierestrass representation) is a way to construct harmonic maps into symmetric spaces, that was developed by J. Dorfmeister, F. Pedit, H. Wu (see [3]). The Gauss map of a constant mean curvature (CMC) surface in $\mathbb{R}^3$ or $\mathbb{R}^{2,1}$ is a harmonic map, thus the DPW method is useful for studying CMC-surfaces. The Riemann metric of a CMC-surface satisfies the classical Gauss-Codazzi equation, so the DPW method is also useful for studying certain nonlinear differential equations. In the case of $\mathbb{R}^{2,1}$, the Gauss-Codazzi equation can be regarded as the sinh-Gordon equation. Since the sinh-Gordon equation is a special case of the tt*-Toda equation, solutions of the sinh-Gordon equation have some interpretation from physics such as $N = 2$ supersymmetric quantum field theories [1] and quantum cohomology [2].

In the DPW method, we obtain a harmonic map from the Iwasawa factorization of a matrix-valued function L corresponding to a certain holomorphic 1-form. However, the Iwasawa factorization is not always global. Thus, the globality of the Iwasawa factorization is an important problem. In [2], J. Dorfmeister, M. Guest and W. Rossman gave the Iwasawa factorization of L near $z = 0 \in \mathbb{C}$ for the case of Smyth potential on $\mathbb{C}^*$. In this talk, we show that L can be expressed in terms of the Bessel functions and from the asymptotic expansion of the Bessel functions we give an Iwasawa factorization at large $z \in \mathbb{C}^*$. Using this, we obtain the global Iwasawa factorization and the global solution of the sinh-Gordon equation.

References

[1] S. Cecotti and C. Vafa, Topological-anti-topological fusion, Nuclear Phys. B 367 (1991), 359 – 461.

[2] J. Dorfmeister, M. Guest, and W. Rossman, The tt^* structure of the quantum cohomology of $\mathbb{C}P^1$ from the viewpoint of differential geometry, Asian J. Math. 14 (2010) 417 – 438.

[3] J. Dorfmeister, F. Pedit, and H. Wu, Weierstrass type representation of harmonic maps into symmetric spaces, Comm. Anal. Geom. 6 (1998), no. 4, 633 – 668.

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Inviscid limits for the Keller-Segel-Navier-Stokes system of parabolic-elliptic type

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In this talk, we show the local well-posedness for the Keller-Segel-Navier-Stokes system of parabolic-elliptic type with initial data in the Sobolev spaces, where the solution is uniformly bounded with respect to the viscous coefficient $\nu > 0$. In addition, we obtain inviscid limits for the system. The method is based on the argument due to Kato (1972). More precisely, we prove the a priori estimate of the system which is independent of ν. Then, by virtue of the a priori estimate, even if the existence time interval of the solutions which we construct may depend on ν, we may show that the solutions exist independently of ν by repeating construction of solutions with replacing initial data. Here, to establish the a priori estimate, we make use of the commutator estimate shown by Kato and Ponce (1988). Moreover, to obtain inviscid limits, we follow the approach by Kato and Lai (1984). Them method allows us to show the existence of inviscid limits which converge in the same regularity as that of the spaces of the initial data.

Wednesday, December 7th, 2022

Existence of weak solution to the nonstationary Navier-Stokes equations approximated by pressure stabilization method

Takayuki Kubo

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In this talk, we consider the weak solution to the nonstationary Navier- Stokes equations approximated by the pressure stabilization method in bounded $C^{2,1}$ domain. By using the $L_p - L_q$ maximal regularity theorem, we prove the existence theorem for the weak solution to our problem. Moreover for $n = 2$, we also prove the uniqueness theorem for the weak solution to our problem.

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Global solutions for the incompressible rotating MHD equations in the scaling critical Sobolev space

Ryo Takada

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In this talk, we consider the initial value problem for the incompressible magnetohydrodynamics equations with the Coriolis force in the whole space $\mathbb{R}^3$. We prove the global in time existence and the uniqueness of solutions for large initial data in the scaling critical Sobolev space $\dot{H}^{\frac{1}{2}}(\mathbb{R}^3)$ when the speed of rotation is sufficiently high. In order to control the large magnetic field, we introduce a modified linear solution for the velocity, and show its smallness in a suitable space-time norm by means of the dispersive effect of the Coriolis force. This talk is based on the joint work with Keiji Yoneda (Kyushu University).

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On the asymptotic stability for the quantum Hall-MHD via $\widehat{L^p}$ energy methods

Ryosuke Nakasato

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We consider the initial-value problem for the compressible Hall-magnetohydrodynamic system with quantum effects in the 3-dimensional Euclidean space $\mathbb{R}^3$. The system is used to model for the *magnetic reconnection phenomenon*, that is not able to be explained by the well-known magnetohydrodynamic system. The aim of this talk is to obtain time-decay estimates for solutions as a perturbation from a constant equilibrium state $(1, 0, \bar{B})$ in a critical L^p framework. Here $\bar{B} \in \mathbb{R}^3$ is denoted by constant magnetic fields. To obtain such a result, we establish energy methods on Fourier–Herz spaces $\widehat{L^p}$ introduced by Grünrock (2004). By combining $\widehat{L^p}$ energy methods and a transformation of the momentum equation given by the effective velocity, we will derive the $\widehat{L^p}$-$\widehat{L^{p/2}}$ type time-decay estimate without the smallness requirement of low frequencies for initial data.

Planar Navier-Stokes flows with flux in exterior domains

Mitsuo Higaki

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We consider the two-dimensional Navier-Stokes system in exterior domains. The system has an exact stationary solution with the scale-critical decay, written as a linear combination of the flux carrier and the pure rotating flow. Our main concern is the analysis of the linearized Navier-Stokes system around these solutions. The following results will be reported: a) Subcritical decay for the stationary solutions; b) L^p-L^q estimates of the nonstationary solutions. As applications, one can prove the existence of non-symmetric stationary Navier-Stokes flows with the critical decay and the stability of the exact solutions under initial L^2-perturbation. We will explain in detail how the non-zero flux is involved in the analysis.

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Large time behavior of solutions to the Navier-Stokes equations in exterior Lipschitz domains

Keiichi Watanabe

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Consider the three-dimensional Navier-Stokes equations in an exterior *Lipschitz* domain Ω. In this talk, we show the unique existence of a global *strong* solution u to the Navier-Stokes equations and investigate the large time behavior of the solution u. To this end, we prove several mapping properties of the Stokes semigroup, including the local energy decay estimate for the Stokes semigroup. In particular, we obtain the same asymptotic behavior of the Stokes semigroup as given in Iwashita (1989) and Maremonti and Solonnikov (1997), nevertheless the boundary $\partial\Omega$ is not smooth. Although there are some restrictions on p and q to get L^p-L^q mapping properties of the Stokes semigroup and its gradient due to the roughness of the boundary $\partial\Omega$, the large time behavior of the Navier-Stokes flow is completely recovered in the exterior Lipschitz domain Ω along exactly the *same* argument as usual. A new decay estimate of the pressure in some annulus will be also explained, which is a crucial part of the proof.

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Contact Line Dynamics I - Modeling and Regularity of Solutions

Matthias Köhne

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We introduce a basic model for contact line dynamics in the context of two-phase flows and discuss various questions concerning the modeling and the existence, uniqueness and regularity of solutions. Moreover, we compare our observations with known results for related problems in wedge type domains. The results presented originate from joint works with Dieter Bothe, Christiane Bui, Mathis Fricke, Jürgen Saal and Laura Westermann.

Contact Line Dynamics II - Maximal Regularity in the Weak Setting

Jürgen Saal[†]

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Rigorous analytical treatment of models related to contact line dynamics have been a great and fascinating challenge for decades now. In this talk we consider one of the most fundamental 2D models in this context. Its well-posedness seems still to be open. We will not be able to present the "final" result, but some promising steps towards its well-posedness. In particular, we will present a maximal regularity result on the corresponding linearized Stokes system. A suitable handling of the corresponding Stokes equations seems to be the crux of the entire problem. We will also explain how our approach can help to get closer to a "final" result. This is a joint project with Christiane Bui and Matthias Köhne.

[†]The speaker will give his talk via Zoom, which is projected onto the screen of the conference room.

Thursday, December 8th, 2022

Classical solution for the compressible flow with free surface in three dimensional exterior domain

Xin Zhang

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In this talk, we discuss about the problem concerning the motion of the barotropic compressible Navier-Stokes equations (CNS) in the smooth exterior domain with some free surface. By applying the method of Lagrangian coordinates, the nonlinear problem reduces to the study of the Lame system with the free boundary conditions. Then the L_p-L_q decay estimates are established for such linearized system, by taking advantage of the local energy approach. At last, we apply the L_p-L_q decay theory to construct the global solution of (CNS). In particular, we have established the classical Matsumura-Nishida theory for the free boundary value problem via the partial Lagrangian approach. The results above are based on the joint works with Prof. Yoshihiro Shibata from Waseda University.

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Existence of solutions to the Navier-Stokes Cauchy problem in the L^3 setting

Paolo Maremonti

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We investigate on the existence of solutions to the Navier-Stokes Cauchy problem with initial datum u_0 in L^3 and divergence free. It is known that this kind of result is not new. Indeed, there is a wide literature on it, with a first contribution due to T. Kato in [3]. Our chief goal is to establish the existence interval $(0, T)$ by uniquely considering the size of the initial datum in L^3 and the absolute continuity of $|u_0(x)|^3$.

A similar analysis has been developed in the recent paper [1], where it is employed the dimensionless weighted functional $||U_0||^2_{wt} := \sup_x \int_{\mathbb{R}^3} \frac{U_0^2(y)}{|x-y|} dy$ and, in the set L^2_{wt}, where $||\cdot||_{wt} < \infty$, the subset of the so called Kato class K_3 is considered. In this regard, we recall that $||\cdot||_{wt}$ is not equivalent to the L^3-norm.

The result, proved in paper [2] for the Cauchy problem, will represent the starting point for the same result, in a forthcoming paper, in the case of the initial boundary value problem in $(0, T) \times \Omega$, where $\partial\Omega$ is assumed a sufficiently regular compact set, or is the half-space.

Keywords: Navier-Stokes equations; existence; regular solutions.

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Global well-posedness of the compressible Navier-Stokes-Korteweg system under critical condition

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Global existence of solutions to the compressible Navier-Stokes-Korteweg system around a constant state is studied. This system describes liquid-vapor two phase flow with phase transition as diffuse interface model. In previous works they assume that the pressure is a monotone function for change of density similarly to the usual compressible Navier-Stokes system. On the other hand, due to phase transition the pressure is accurately non-monotone function and the linearized system loses symmetry in a critical case such that the derivative of pressure is 0 at the given constant state. It is shown that in the critical case for small data whose momentum has derivative form there exist global L^2 solutions and the parabolic type decay rate of the solutions is obtained. The results were obtained in a joint work with K. Tsuda (Kyushu Sangyou University).

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Dissipative structure for the system in electro-magneto-hydrodynamics

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We consider the system in electro-magneto-hydrodynamics, which is a coupled system of the compressible Navier-Stokes equation and the Maxwell equation. The system admits a constant equilibrium state which satisfies

$$\bar{\boldsymbol{E}} + \bar{\boldsymbol{u}} \times \bar{\boldsymbol{B}} = 0,$$

where $\bar{\boldsymbol{u}}$, $\bar{\boldsymbol{E}}$, and $\bar{\boldsymbol{B}}$ are constant states of the velocity, the electric field and the magnetic induction, respectively.

We linearize the system around the constant equilibrium state and study the dissipative structure of the linearized system. This linearized system is not symmetric. However, we can modify it to an equivalent system which is a symmetric hyperbolic-parabolic system in the non-relativistic region $|\bar{\boldsymbol{u}}| < c_0$, where c_0 is the speed of light. We then show that the dissipative structure of the linearlized system is of the standard type and is characterized by

$$\operatorname{Re}\lambda(i\xi) \le -c|\xi|^2/(1+|\xi|^2), \qquad \xi \in \mathbb{R}^3,$$

where $\lambda(i\xi)$ denotes the eigenvalues of the linearized system in the Fourier space and c is a positive constant. Also we can show the corresponding decay estimate of the solutions to the linearized system. The proof is based on the energy method in the Fourier space. Our result is an improvement of the previous result obtained in [1] in a special case where $\bar{\boldsymbol{u}} = \bar{\boldsymbol{E}} = 0$.

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Stability of relaxed multi-d compressible Navier-Stokes equations

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We consider the non-isentropic compressible Navier-Stokes equations in two or three space dimensions for which the heat conduction of Fourier's law is replaced by Cattaneo's law and where the classical Newtonian flow is replaced by a revised Maxwell flow. For two special cases, we demonstrate the global well-posedness of solutions with small initial data resp. the blow-up of solutions in finite time for a class of large initial data. Moreover, the singular limit for vanishing relaxation parameters is investigated.

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Free surface problem of the incompressible Navier-Stokes equations in a scaling critical space

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We consider the free surface problem of the incompressible Navier-Stokes equations near the half Euclidean space. It is well known that the Cauchy problem of the Navier-Stokes equations has a invariant scaling and Fujita-Kato's principle tells us that the problem can be solved globally in a scaling invariant class. We first transform the problem into a fixed region of the half Eucldean space and then consider the problem as the initial - boundary problem in the scaling critical Besov space. Maximal L^1 regularity and the multiple nonlinear estimates are the main tools for the proof. To establish maximal L^1 regularity, we apply the Shibata-Shimizu formula of the Stokes equations for free stress boundary condition. This talk is based on a joint work with Senjo Shimizu (Kyoto University).

Friday, December 9th, 2022

Method of Modified Energy

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This talk in on the method of modified energy for the apriori control of the H^2-norm for strong solutions for dispersive equations.

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A localized maximum principle and an application to the critical SQG on bounded domain

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In this talk, we consider the surface quasi-geostrophic equation with the critical dissipation on bounded domains. Motivated by the Littlewood Paley decomposition with dyadic numbers, we establish a frequency localized maximum principle in the L^∞ ramework. In addition, we also establish the commutator estimate of the derivatives and the spectral restriction operator, defined by the spectral multuplier.

A new class of small initial data which may shift the lifespan estimates for the classical damped wave equations

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The talk is based on a joint work with K.Fujiwara. Lifespan of solutions to semilinear classical damped wave equation is investigated when the sum of initial position and speed is zero pointwisely. It is shown that lifespan is extended with appropriate initial data and the critical exponent for global existence is shifted for non-integrable data.