WASEDA University · TECHNISCHE UNIVERSITÄT DARMSTADT · THE UNIVERSITY OF TOKYO

International Research Training Group 1529

Mathematical Fluid Dynamics

Autumn School and Workshop

Bad Boll, Germany
October 27 – 30, 2014

Lecture Series

Peter Constantin, Princeton
PDE Problems of Hydrodynamic Origin

Yasunori Maekawa, Sendai
Analysis of Incompressible Flows in Unbounded Domains

László Székelyhidi, Leipzig
The h-Principle in Fluid Mechanics and Onsager's Conjecture

Confirmed Speakers

K. Abe (Nagoya)
H. Abels (Regensburg)
D. Bothe (Darmstadt)
L. Brandolese (Lyon)
R. Danchin (Paris)
K. Disser (Berlin)
R. Farwig (Darmstadt)
E. Feireisl (Prague)
T. Hishida (Nagoya)
J. Kelliher (Los Angeles)
H. Koch (Bonn)
M. Kyed (Kassel)
M. Lopes Filho (Rio de Janeiro)
P. Maremonti (Naples)
P. Mucha (Warsaw)
Š. Nečasová (Prague)
J. Prüss (Halle)
M. Schoenbek (Santa Cruz)
F. Sueur (Paris)
R. Takada (Sendai)
W. Varnhorn (Kassel)
E. Zatorska (Warsaw)

Organizers:

M. Hieber
H. Kozono

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Deutsche Forschungsgemeinschaft DFG

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1 Program

Autumn School "Mathematical Fluid Dynamics", Bad Boll, October 27 - 30, 2014

Time	Monday	Tuesday	Wednesday	Thursday
8:55 - 9:00	Opening			
9:00h - 9:50h	**Constantin**	**Székelyhidi**	**Maekawa**	**Constantin**
10:00h - 10:50h	**Maekawa**	**Constantin**	**Székelyhidi**	**Maekawa**
11:00h - 11:30h	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
11:30h - 11.55h	Brandolese	Abe	Zatorska	Takada
12:00h - 12:25h	Hishida	Kelliher	Lopes-Filho	Feireisl
12:30h - 14:00h	*Lunch*	*Lunch*	*Lunch*	*Lunch*
14:00h - 14:50h	**Székelyhidi**	**Maekawa**	**Constantin**	**Székelyhidi**
15:00h - 15:30h 15:00h - 15:45h	6 short presentations	6 short presentations	9 short presentations	6 short presentations
15:30h - 16:15h	*Coffee Break*	*Coffee Break*	*Coffee Break*	*Coffee Break*
16:15h - 16:40h	Danchin	Koch	Tucsnak	Abels
16:45h - 17:10h	Maremonti	Mucha	Necasová	Prüß
17:15h - 17:40h	Kyed	Disser	Lukácová	*Closure*
17:45h - 18:10h	Varnhorn	Ziegler		
18:30h	*Reception*	*Dinner*	*Dinner*	
20:00h - 20:25h		Shibata		
20:30h - 20:55h		Bothe		

Monday, 27. October 2014

Time	Speaker	*Title of Talk*
08:55-09:00		OPENING
09:00-09:50	P. Constantin	*PDE Problems of Hydrodynamic Origin*
10:00-10:50	Y. Maekawa	*Analysis of Incompressible Flows in Unbounded Domains*
11:00-11:30		COFFE BREAK
11:30-11:55	L. Brandolese	*Blowup issues for water wave propagation in shallow water*
12:00-12:25	T. Hishida	*Stability of time-dependent Navier-Stokes flow and algebraic energy decay*
12:30-14:00		LUNCH
14:00-14:50	L. Székelyhidi	*The h-Principle in Fluid Mechanics and Onsager's Conjecture*
15:00-15:30		*Short Talks, see page 7*
15:30-16:15		COFFEE BREAK
16:15-16:40	R. Danchin	*Radiative flows and critical Besov spaces*
16:45-17:10	P. Maremonti	*A sort of continuous dependance on data for a suitable weak solution to the Navier-Stokes Cauchy problem*
17:15-17:40	M. Kyed	*Weak time-periodic solutions to the Navier-Stokes equations in the three-dimensional whole-space with a non-zero drift term: Asymptotic profile at spatial infinity*
17:45-18:10	W. Varnhorn	*On the non-homogeneous Navier-Stokes equations*
18:30-21:00		RECEPTION

Tuesday, 28. October 2014

Time	Speaker	*Title of Talk*
09:00-09:50	L. Székelyhidi	*The h-Principle in Fluid Mechanics and Onsager's Conjecture*
10:00-10:50	P. Constantin	*PDE Problems of Hydrodynamic Origin*
11:00-11:30		COFFE BREAK
11:30-11:55	K. Abe	*The Navier-Stokes equations in a space of bounded functions*
12:00-12:25	J. Kelliher	*Serfati's approach to vortex patches*
12:30-14:00		LUNCH
14:00-14:50	Y. Maekawa	*Analysis of Incompressible Flows in Unbounded Domains*
15:00-15:30		*Short Talks, see page 7*
15:30-16:15		COFFEE BREAK
16:15-16:40	H. Koch	*Radiative flows and critical Besov spaces*
16:45-17:10	P. Mucha	*Mathematical cocktails: weak solutions*
17:15-17:40	K. Disser	*Asymptotic behaviour of a rigid body with a cavity filled by a viscous liquid*
17:45-18:10	M. Ziegler	*Computational Theory of Function Spaces*
18:30-20:00		DINNER
20:00-20:25	Y. Shibata	*On a global well-posedness of strong dynamics of Incompressible Nematic Liquid Crystals in* R^N
20:30-20:55	D. Bothe	*Modeling and analysis of multicomponent transport in fluid systems with ionic species*

Wednesday, 29. October 2014

Time	Speaker	*Title of Talk*
09:00-09:50	Y. Maekawa	*Analysis of Incompressible Flows in Unbounded Domains*
10:00-10:50	L. Székelyhidi	*The h-Principle in Fluid Mechanics and Onsager's Conjecture*
11:00-11:30		COFFE BREAK
11:30-11:55	E. Zatorska	*Low Mach Number Limit for the Multicomponent Reactive Mixture Model*
12:00-12:25	M. Lopes Filho	*The limit of small viscosity and small elastic response for the second-grade fluid equations*
12:30-14:00		LUNCH
14:00-14:50	P. Constantin	*PDE Problems of Hydrodynamic Origin*
15:00-15:45		*Short Talks, see page 8*
15:45-16:15		COFFEE BREAK
16:15-16:40	M. Tucsnak	*Free and controlled particles in viscous incompressible flows*
16:45-17:10	Š. Nečasová	*Low Mach number limit and diffusion limit in a model of radiative flow*
17:15-17:40	M. Lukáčová	*Existence, uniqueness and approximation of some diffusive viscoelastic flows*
18:30-		DINNER

Thursday, 30. October 2014		
Time	Speaker	*Title of Talk*
09:00-09:50	P. Constantin	*PDE Problems of Hydrodynamic Origin*
10:00-10:50	Y. Maekawa	*Analysis of Incompressible Flows in Unbounded Domains*
11:00-11:30		COFFE BREAK
11:30-11:55	R. Takada	*Remarks on the Strichartz estimates for the rotating incompressible fluids*
12:00-12:25	H. Abels	*Well-Posedness and Stability for the Volume-Preserving Mean Curvature Flow with a Dynamic Contact Angle*
12:30-14:00		LUNCH
14:00-14:50	L. Székelyhidi	*The h-Principle in Fluid Mechanics and Onsager's Conjecture*
15:00-15:30		*Short Talks, see page 8*
15:30-16:15		COFFEE BREAK
16:15-16:40	E. Feireisl	*Regularity of weak solutions to the full Navier-Stokes-Fourier system*
16:45-17:10	J. Prüss	*Maxwell-Stefan Diffusion in Reactive Multicomponent Flows*
17:15-17:40		CLOSURE

2 Short Talks

Monday, 27. October 2014

Time	Speaker	*Title of Talk*
15:00-15:05	T. Iwabuchi	*On the large time behavior of solutions for the critical Burgers equation*
15:05-15:10	C. Förster	*Wild initial data for the incompressible Euler equation*
15:10-15:15	M. Bolkart	*Strong Stability of the Stokes Semigroup in Spaces of Bounded Functions*
15:15-15:20	M. Kalousek	*Homogenization of a non-Newtonian flow through a porous medium*
15:20-15:25	C. Nobili	*Turbulent Convection at finite Prandtl number*
15:25-15:30	T. Kato	*Time decay estimates for dispersive equations*

Tuesday, 28. October 2014

Time	Speaker	*Title of Talk*
15:00-15:05	A. Tarfulea	*Regularity and Finite-dimensional Attractor for the Critical Surface Quasigeostrophic Equation*
15:05-15:10	M. Saal	*Nonlinear Integro-Differential Equations*
15:10-15:15	C. Schmäche	*Non-smooth isometric embeddings of surfaces*
15:15-15:20	T. Seitz	*Flow identification from MRV measurements*
15:20-15:25	T. Suzuki	*Analyticity of semigroups generated by higher order elliptic operators in spaces of bounded functions on C^1 domains*
15:25-15:30	E. Ushikoshi	*Hadamard variational formula for the eigenvalue of the Stokes equations*

Wednesday, 29. October 2014

Time	Speaker	*Title of Talk*
15:00-15:05	Y. Terasawa	*Sharp weighted maximal function estimate in some martingale setting*
15:05-15:10	J. Sauer	*Strong Stability of 2D Viscoelastic Poiseuille-type Flows, Part 1*
15:10-15:15	K. Schade	*Strong Stability of 2D Viscoelastic Poiseuille-type Flows, Part 2*
15:15-15:20	G. Takahashi	*Extension criterion on strong solutions to the Navier-Stokes equations*
15:20-15:25	G. Yanqiu	*Inertial manifolds for certain sub-grid scale alpha-models of turbulence*
15:25-15:30	M. Egert	*Elliptic boundary value problems on cylindrical domains*
15:30-15:35	B. She	*Numerical simulation of a diffusive Oldroyd-B model*
15:35-15:40	N. Mori	*Dissipative Timoshenko system versus Timoshenko-Cattaneo system*
15:40-15:45	S. Meyer	*On a two-phase weak Neumann problem*

Thursday, 30. October 2014

Time	Speaker	*Title of Talk*
15:00-15:05	H. Koba	*On fluid-flow on an evolving hypersurface*
15:05-15:10	P. Tolksdorf	*The Navier-Stokes equations on bounded Lipschitz domains*
15:10-15:15	T. Okabe	*Remark on the asymptotic expansion of the Naveir-Stokes flow in the whole space*
15:15-15:20	A. Dalinger	*On the hydrodynamic behavior of a 1D system with next neighbour interactions*
15:20-15:25	H. Mizerová	*Regularity of weak solution to the diffusive Peterlin model*
15:25-15:30	D. Noboriguchi	*Stochastic Scalar Conservation Laws with Dirichlet boundary conditions*

3 Abstracts

The Navier-Stokes equations in a space of bounded functions

Ken Abe

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We consider blow-up rates of the Navier-Stokes flow for domains with boundaries subject to the non-slip boundary condition. It is known that the type I blow-up of the Navier-Stokes flow in the whole space or a half space is a minimum rate at which a singularity can develop. We develop an existence theorem on L^∞ for domains with curved boundaries by means of L^∞-estimates for the Stokes semigroup and deduce the minimum blow-up rate.

Well-Posedness and Stability for the Volume-Preserving Mean Curvature Flow with a Dynamic Contact Angle

Helmut Abels

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We will consider the dynamic stability of a spherical cap on a flat plane in three space dimensions with a dynamic boundary condition which is associated to an energy of the contact line between the spherical cap and the plane. Using a suitable parametrization we can apply results on maximal L^p-regularity for parabolic equations with dynamic boundary conditions and a generalized principle of linearized stability. To this end a careful analysis of the spectral properties of the linearized operator is needed.

Modeling and analysis of multicomponent transport in fluid systems with ionic species

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Ionic species in fluid systems are subject to Coulomb forces due to the intrinsic electrical field generated by their charges. This leads to a drift contribution, the so-called electromigration, to the transport of the ions. We give a thermodynamically consistent derivation of electromigration based on the Maxwell-Stefan approach to multicomponent transport and discuss the wellposedness of several prototype models.

Blowup issues for water wave propagation in shallow water

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We study the formation of singularities in strong solutions of one-dimensional asymptotic models derived from the free-surface irrotational Euler equation in the shallow water and moderate amplitude regime. Such models include, *e.g.*, the Camassa–Holm equation and the Degasperis–Procesi equation. We will provide a new blowup criterion that allow us to unify some of the earlier best known blowup results. The presented models are also relevent in the study of vibrations inside hyperelastic materials and in numerical regularizations of turbulent flows.

This is a partially joint work with Fernando Cortez.

References

[1] L. Brandolese, *Local-in-space criteria for blowup in shallow water and dispersive rod equations*, Comm. Math. Phys. **330**, N. 1 (2014), 401–414.

[2] L. Brandolese, M. F. Cortez, *On permanent and breaking waves in hyperelastic rods and rings,* J. of Funct. Anal. **266** (2014), 6954–6987.

[3] L. Brandolese, *A Liouville theorem for the Degasperis-Procesi equation*, preprint, arXiv:1405.6675.

Radiative flows and critical Besov spaces

Raphaël Danchin

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We consider a simplified model arising in radiation hydrodynamics. It is based on the barotropic Navier-Stokes system describing the macroscopic fluid motion, and the P1-approximation of the transport equation modeling the propagation of radiative intensity. Under a necessary and sufficient linear stability condition, we establish the global-in-time existence of strong solutions for small perturbations of a stable radiative equilibrium. Local existence is proved for any large data with critical regularity, and density bounded away from zero. This is a joint work with B. Ducomet. Dynamics which is based on the barotropic Navier-Stokessystem describing the macroscopic uid motion, and theso-called P1-approximation of the transport equationmodeling the propagation of radiative intensity. We establish global-in-time existence of strong solutions for theassociated Cauchy problem when initial data are closeto a stable radiative equilibrium, and local existence forlarge data with no vacuum.We all also discuss the low mach number limit and variousdiusive asymptotics.

Asymptotic behaviour of a rigid body with a cavity filled by a viscous liquid

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We discuss the system of equations modeling the free motion of a rigid body with a cavity filled by a viscous liquid. Zhukovskiy's Theorem states that in the limit $t \to \infty$, the relative fluid velocity tends to zero and the rigid velocity of the full structure tends to a steady rotation around one of the principle axes of inertia. We show that every (reasonable) weak solution is subject to Zhukovskiy's Theorem – i.e. that it applies to finite-energy initial data of arbitrary size. In particular, the weak solutions constructed in [2] are of this type.

For this system, the kinetic energy provides a strict Lyapunov functional for (regular) solutions, whereas total angular momentum is preserved. One of the main points in the proof is to show that despite this conservative aspect and in the absence of stability, weak solutions become regular eventually. For large-time trajectories, a suitable version of LaSalle's invariance principle then applies.

References

[1] Karoline Disser. Asymptotic behaviour of a rigid body with a cavity filled by a viscous liquid. WIAS Preprint 1958, 2014.

[2] Ana L. Silvestre and Takeo Takahashi. On the motion of a rigid body with a cavity filled with a viscous liquid. Proc. Roy. Soc. Edinburgh Sect. A, 142(2):391423, 2012.

Regularity of weak solutions to the full Navier-Stokes-Fourier system

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We discuss the problem of regularity and conditional regularity of weak solutions to the full Navier-Stokes-Fourier system. Applications will be given to convergence problems of the associated numerical schemes.

Stability of time-dependent Navier-Stokes flow and algebraic energy decay

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Let $V = V(x,t)$ be a given time-dependent Navier-Stokes flow of an incompressible viscous fluid in the whole space $\mathbb{R}^n$ $(n = 3,4)$. As important examples of this basic flow V, we have the following in mind: forward self-similar solution, time-periodic solution and global mild solution of the Cauchy problem. It is thus reasonable to assume that $V \in L^\infty(0,\infty; L^{n,\infty}) \cap C_w([0,\infty); L^{n,\infty})$, where $L^{n,\infty}$ denotes the weak-L^n space. The energy stability of small V in this class with respect to any initial disturbance in L^2_σ has been investigated by [1]. In this presentation we would like to discuss structure of energy decay rate of disturbance for $t \to \infty$.

This talk is based on a joint work with Maria E. Schonbek (University of California, Santa Cruz).

References

[1] G. Karch, D. Pilarczyk and M.E. Schonbek, L^2-asymptotic stability of mild solutions to the Navier-Stokes system of equations in $\mathbb{R}^3$, Preprint, arXiv:1308.6667.

Serfati's approach to vortex patches

James P. Kelliher

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We discuss Ph. Serfati's proof of the persistence of regularity of the boundary of a two-dimensional vortex patch. This proof, published in a four-page paper in 1994, was preceded by two earlier proofs of the same result, one by Chemin and the other by Bertozzi and Constantin. Though Serfati's proof clearly owes much to each of these prior proofs, it is elegant, elementary, and quite novel. Some of its ideas, buried for two decades, have applications to problems of current interest, in particular to the propagation of local regularity. We speak of this and other applications. This is a report on joint work with Hantaek Bae of UC Davis.

The Kadomtsev-Petviashvili II equation in 3d

Herbert Koch

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The Kadomtsev-Petviasvhili II equation describes wave propagating in one direction with weak transverse effect. I will explain the proof of global existence and scattering for three space dimensions. The key estimates are bilinear L^2 estimates and a delicate choice of norms. This is joint work with Junfeng Li.

Weak time-periodic solutions to the Navier-Stokes equations in the three-dimensional whole-space with a non-zero drift term: Asymptotic profile at spatial infinity

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Results on the asymptotic structure at spatial infinity of solutions to the time-periodic Navier-Stokes system in the three-dimensional whole-space with a non-zero drift term will be presented. We will introduce a large class of weak time-periodic solutions and establish an asymptotic expansion as $|x| \to \infty$ for the members of this class. The asymptotic profile will be explicitly identified in terms of the Oseen fundamental solution. Moreover, a pointwise estimate will be given for the remainder term. This estimate will manifest a parabolic wake region in the solution.

The limit of small viscosity and small elastic response for the second-grade fluid equations

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In this talk we consider the second-grade fluid system with viscosity ν and elastic response parameter α, in a two-dimensional smooth bounded domain with smooth initial data and no-slip boundary conditions. For a suitably defined converging family of initial data, we consider a corresponding family of solutions to these equations depending on these parameters. We examine the limits of vanishing α and ν, obtaining, for certain regimes, convergence to solutions of the incompressible Euler equations, while in other regimes, we obtain sharp conditions for convergence analogous to Kato's criterion. This talk is based on joint work with H. Nussenzveig Lopes, E. Titi and A. Zang.

Existence, uniqueness and approximation of some diffusive viscoelastic flows

Mária Lukáčová-Medvid'ová

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In this talk we will present our recent results on the so-called diffusive Peterlin model, which can be obtained by a suitable approximation of a nonlinear bed-spring force. Consequently we obtain a macroscopic model for the conservation of mass, momentum and time evolution of the conformation stress tensor, which takes into account also diffusive effects.

We will study existence and regularity of weak solutions in two and three space dimensions and show corresponding uniqueness for more regular solutions, cf. [1]. Having obtained uniqueness and regularity result we propose a numerical scheme for the approximation of the diffusive Peterlin model that is based on the characteristics finite element method, cf. [3,4]. Finally we will show that using $P_1/P_1 stab/P_1$ finite element approximation for the velocity, pressure and conformation tensor we obtain the first order error estimates, cf. [2].

The present work has been supported by the German Science Foundation (DFG) under IRTG 1529 “Mathematical Fluid Dynamics" and realized in collaboration with H. Mizerová, Š. Nečasová, M. Renardy, M. Tabata, H. Notsu and B. She.

References

[1] M. Lukáčová-Medvid'ová, H. Mizerová, Š. Nečasová: *Global existence and uniqueness results for the diffusive Peterlin viscoelastic model*, Preprint, University of Mainz, 2014.

[2] M. Lukáčová-Medvid'ová, H. Mizerová, H. Notsu, M. Tabata: *Error estimates of a pressure-stabilized characteristics finite element scheme for the diffusive Oseen-Peterlin model*, in preparation.

[3] H. Notsu, M. Tabata: *A single-step characteristic-curve finite element scheme of second order in time for the incompressible Navier-Stokes equations*, J. Sci. Comput. 38 (2009), no. 1, 1-14.

[4] H. Notsu, M. Tabata: *Error estimates of a pressure-stabilized characteristics finite element scheme for the Oseen equations*, WIAS Discussion Paper 2013, no. 1, 1-19.

A sort of continuous dependance on data for a suitable weak solution to the Navier-Stokes Cauchy problem

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As it is known, in [1] is proved the partial regularity for suitable solutions to the Navier-Stokes Cauchy problem. In particular, it is proved that a suitable weak solution becomes “regular” in the exterior of a suitable ball B_R. The aim of our study is to investigate, for a suitable weak solution, a sort of continuous dependence. More precisely, we are interested to point out a bound and the behavior in t, in a neighborhood of $t = 0$, of $L^\infty(\mathbb{R}^3 - B_R)$-norm of solutions and also the pointwise behavior of the solutions for large $|x| > R$, provided that a one exists for the initial data.

The results are part of the papers [2,3].

References

[1] Caffarelli L., Kohn R. and Nirenberg L., Partial regularity of suitable weak solutions of the Navier-Stokes equations, CPAM, 35 (1982).

[2] Crispo F. and Maremonti P., A remark on the partial regularity of a suitable weak solution to the Navier-Stokes Cauchy problem, forthcoming.

[3] Crispo F. and Maremonti P., On the spatial-time decay of a suitable weak solutions to the Navier-Stokes Cauchy problem, forthcoming.

Mathematical cocktails: weak solutions

Piotr Mucha

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The aim of the talk is analysis of a model describing motion of chemically reacting heat-conducting gaseous mixtures, based on a modification of the compressible Navier- Stokes equations. The key point is thermodynamical well posedness of the studied model. I would like to focus on presenting the detailed approximation scheme for the full system. At least on the first steps.
The talk will base on joint results with Milan Pokorny and Ewelina Zatorska.

Low Mach number limit and diffusion limit in a model of radiative flow

Šárka Nečasová

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We consider an asymptotic regime for a simplified model of compressible Navier-Stokes-Fourier system coupled to the radiation, when hydrodynamical flow is driven to incompressibility through the low Mach number limit. We prove a global-in-time existence for the primitive problem in the framework of weak solutions and for the incompressible target system and we study the convergence of the primitive system toward its incompressible limit. Moreover,we investigate the cases when the radiative intensity is driven either to equilibrium or to non-equilibrium diffusion limit, depending the scaling performed, and we study the convergence of the system toward the aforementioned limits.Finally, we consider a ”semi-relativistic" model of radiative viscous compressible Navier-Stokes-Fourier system coupled to the radiative transfer equation extending the classical model introduced in [3] and we study some of its singular limits (low Mach and diffusion).

References

[1] B. Ducomet, Š. Nečasová, Low Mach number limit in a model of radiative flow, J. Evol. Equ. 14 (2014), **2**, 357–385.

[2] B. Ducomet, Š. Nečasová, Diffusion limits in a model of radiative flow, Ann Univ Ferrara DOI 10.1007/s11565-014-0214-3.

[3] B. Ducomet, E. Feireisl, Š. Nečasová, On a model of radiation hydrodynamics. Ann. I. H. Poincaré-AN **28** (2011), 797–812.

[4] B. Ducomet, Š. Nečasová, Singular limits in a model of radiative flow, Preprint 2014.

Maxwell-Stefan Diffusion in Reactive Multicomponent Flows

Jan Prüss

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We consider one-phase reactive multi-component flows where diffusion is modeled by the Maxwell-Stefan approach. Based on abstract results on quasi-linear parabolic evolution equations, we show local well-posedness of the system in an L_p-setting, and construct the resulting local semiflow. The equilibria of the system are identified and are shown to be exponentially, employing the generalized principle of linearized stability. Further, the free energy of the system defines a strict Ljapunov-functional, and by this we show that solutions which do not develop singularities converge to a single equilibrium. (Joint work with M. Wilke)

References

[1] V. Giovangigli: *Multicomponent flow modeling*. Birkhäuser, Basel (1999).

[2] D. Bothe, W. Dreyer: *Continuum thermodynamics of chemically reacting fluid mixtures*, preprint 2014.

[3] M. Herberg, M. Meyries, J. Prüss, M. Wilke: *Reaction-diffusion systems of Maxwell-Stefan type with reversible mass-action kinetics*, preprint, submitted 2013.

[4] J. Prüss, G. Simonett, and R. Zacher:*On convergence of solutions to equilibria for quasilinear parabolic problems*, Journal of Differential Equations, 246, 3902–3931 (2009).

On a global well-posedness of strong dynamics of Incompressible Nematic Liquid Crystals in R^N

Yoshihiro Shibata

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I will talk about some technique how to prove a global well-posedness of strong solutions at least small initial data for some system of parabolic equations by some combination of maximal L_p-L_q regularity with L_p-L_q decay estimate in a unbounded domain. This is a joint work with Maria Schoenbek.

Remarks on the Strichartz estimates for the rotating incompressible fluids

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In this talk, we consider the Strichartz estimates for the linear propagator $e^{\pm it\frac{D_3}{|D|}}$ generated by the Coriolis force $e_3 \times u$:

$$\left\| e^{\pm it\frac{D_3}{|D|}} P_0 f \right\|_{L_t^q L_x^r} \lesssim \|f\|_{L_x^2}.$$

Here $P_0 f$ is a frequency projection operator defined by $\widehat{P_0 f} = \varphi(|\xi|)\widehat{f}$, $\varphi \in C_c^\infty((\frac{1}{2}, 2))$. In our previous work [1], we derived the optimal admissible range

$1/q + 1/r \leqslant 1/2$ for the above space-time estimates. In this talk, we shall give an improvement for the admissible relation under the action of differential operators. Also, we shall discuss a generalization to the rotating stratified fluids.

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Free and controlled particles in viscous incompressible flows

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We study the nonlinear system coupling PDEs and ODEs which models the motion of rigid bodies in a viscous incompressible fluid. We first consider consider the case in which particles are *free*, i.e., under the influence of hydrodynamic forces only, and we recall some of the methods used to solve the difficulties encountered in the mathematical analysis of this problem (the main one being the presence of a free boundary).

We next study two control problems for solids moving in a viscous incompressible fluid. In the first one, the aim consists in steering the bodies to prescribed positions by means of exterior forces acting on them. We show, in particular, that in the presence of control forces we can obtain existence and uniqueness results which are better than in the uncontrolled case. The second control mechanism consists in appropriate deformation of the solids: this is the swimming problem.

On the non-homogeneous Navier-Stokes equations

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The investigation presented here is a joint work with Reinhard Farwig (TU Darmstadt) and Hermann Sohr (U Paderborn): Consider a bounded domain $\Omega \subseteq \mathbb{R}^3$ with smooth boundary $\partial\Omega$, a time interval $[0,T)$, $0 < T \leq \infty$, and in $[0,T) \times \Omega$ the non-homogeneous Navier-Stokes system

$$u_t - \Delta u + u \cdot \nabla u + \nabla p = f, \qquad u|_{t=0} = u_0, \qquad \operatorname{div} u = k, \qquad u|_{\partial\Omega} = g,$$

with sufficiently smooth data f, u_0, k, g. In this general case there are mainly known two classes of weak solutions, the class of global weak solutions, similar as in the well known case $k = 0$, $g = 0$, which need not be unique, and the class of local very weak solutions, see [1], [2], [3], which are uniquely determined, but need neither have differentiability properties nor satisfy the energy inequality. Our aim is to introduce a new class of local strong solutions for the general case $k \neq 0$, $g \neq 0$, satisfying similar regularity and uniqueness properties as in the known case $k = 0$, $g = 0$. For slightly restricted data this class coincides with the corresponding class of very weak solutions yielding new regularity results. Further, through the given data we obtain a control on the interval of existence of the strong solution (compare [4], [5]).

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Low Mach Number Limit for the Multicomponent Reactive Mixture Model

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This talk will be devoted to existence result for the low Mach number limit system obtained from the full compressible Navier-Stokes model for multicomponent reactive mixture. We will first present the compressible model [2] and explain the issue of global in time existence of solutions under special form of the stress tensor [3]. Then we will present derivation of the incompressible system with variable density, called Kazhikhov-Smagulov type model, for a heat-conducting binary mixture. Under special compatibility condition between the viscous tensor and the diffusive term we will prove the existence of global in time weak solutions [1]. The proof relies on the use of a special relative velocity, which is divergence free and which allows to reduce the coupling between particular subsystems. We will also mention possible generalizations of various constraints appearing in the system.

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Computational Theory of Function Spaces

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