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Colloquium Applied Analysis
On the Occasion of Matthias Hieber's Retirement
Darmstadt, June 18th-19th, 2026

Time	Thursday, June 18th	Time	Friday, June 19th
14:00h	Arrival Georg-Lichtenberg-Haus		
14:30h-15:00h	**Welcome Addresses** **J. Giesselmann** **T. Walther** **G. Huisken** **Y. Giga & H. Kozono**	09:00h-09:30h	**G. P. Galdi**
		09:30h-10:00h	**A. Hussein**
		10:00h-10:30h	**P. Korn**
		10:30h-11:00h	*Coffee Break*
15:00h-15:45h	**Colloquium Lecture** **E. S. Titi**	11:00h-11:30h	**Y. Giga**
		11:30h-12:00h	**S. Čanić**
		12:00h-12:30h	**F. Flandoli**
15:45h-16:30h	*Coffee and Refreshments*	12:30h-14:00h	*Lunch*
16:30h-17:15h	**Math Choir & Welcome Addresses** **D. Bothe** **R. Klein & P. Korn** **Postdocs & PhD Students**	14:00h-14:30h	**A. Mazzucato**
		14:30h-15:00h	**S. Shimizu**
		15:00h-15:30h	**A. Agresti**
17:15h-18:00h	**Colloquium Lecture** **R. Denk**	15:30h-16:15h	*Coffee Break*
		16:15h-16:45h	**S. Monniaux**
		16:45h-17:15h	**H. Kozono**
18:00h-19:00h	*Refreshments and Snacks*		
19:00h	*Departure for Dinner*	18:00h	*Departure for Dinner*

Thursday, 18th June 2026

Time	Speaker	Program
14:00		Arrival and Registration Georg-Lichtenberg-Haus
14:30–15:00	J. Giesselmann, Dean, TUDa T. Walther, Vice President, TUDa G. Huisken, Director MFO Y. Giga, University of Tokyo H. Kozono, Waseda University	Welcome Addresses
15:00–15:45	E. S. Titi, University of Cambridge, Texas A&M University, Weizmann Institute	Colloquium Lecture *Turbulent Flows and the Navier-Stokes Enigma: A Mathematical Challenge*
15:45–16:30		*Coffee and Refreshments*
16:30–17:15	Math Choir D. Bothe, TUDa R. Klein, FU Berlin P. Korn, MPI Hamburg Present/ Recent Postdocs & PhD Students, TUDa	 Welcome Addresses
17:15–18:00	R. Denk, Universität Konstanz	Colloquium Lecture *L^p-Perspectives on Deterministic and Stochastic Evolution Equations*
18:00–19:00		Refreshments and Snacks
19:00		Departure for Dinner

Friday, 19th June 2026

Time	Speaker	*Title of Talk*
09:00–09:30	Giovanni P. Galdi (University of Pittsburgh)	*Flow-Induced Oscillations in Fluid-Structure Interactions*
09:30–10:00	Amru Hussein (Universität Kassel)	*The Q-Tensor Model for Liquid Crystals with Arbitrary Ratio of Tumbling and Aligning Effects*
10:00–10:30	Peter Korn (MPI Hamburg)	*From the Ocean to Applied Analysis*
10:30–11:00		Coffee Break
11:00–11:30	Yoshikazu Giga (University of Tokyo)	*On Existence of a Collapsed Bubble with Surface Tension in Viscous Incompressible Fluids*
11:30–12:00	Sunčica Čanić (UC Berkeley)	*A Regularized Interface Method for FSI Problems with Low Regularity Interfaces*
12:00–12:30	Franco Flandoli (SNS Pisa)	*SPDEs for Turbulent Transport*
12:30–14:00		Lunch Break
14:00–14:30	Anna Mazzucato (Penn State University)	*Optimal Mixing in Incompressible Flows*
14:30–15:00	Senjo Shimizu (Kyoto University)	*Free Boundary Problems for the Navier–Stokes Equations in Scaling Critical Spaces*
15:00–15:30	Antonio Agresti (Sapienza University)	*Chasing Regularization by Noise of 3D Navier-Stokes Equations*
15:30–16:15		Coffee Break
16:15–16:45	Sylvie Monniaux (Aix-Marseille University)	*PDEs in Lipschitz Domains*
16:45–17:15	Hideo Kozono (Waseda University)	*Helmholtz-Weyl Decompositon and its Application to the MHD Equations*

19:30		Dinner Mathildenhöhe

Turbulent Flows and the Navier-Stokes Enigma: A Mathematical Challenge

Edriss S. Titi

University of Cambridge,
Texas A&M University,
and
Weizmann Institute of Science
est42@cam.ac.uk

Turbulence is one of the most complex and captivating phenomena in classical physics—an enduring challenge that has fascinated mathematicians, physicists, engineers, and computational scientists alike. While chaos theory emerged in the late 20th century to study seemingly unpredictable behavior across various scientific fields, turbulence has remained the ultimate, elusive prize.

The ability to understand, predict, and control turbulence has profound economic and industrial implications. From reducing drag in cars and airplanes to designing more efficient engines and improving weather and climate forecasts, the stakes are high.

At the heart of turbulence lies the Navier–Stokes equations, which govern the fluid motion. In regimes of high Reynolds numbers—where nonlinear advective forces overwhelm viscous effects—these equations describe the turbulent behavior of fluids. Despite their central role in modeling everything from jet streams to climate systems, the question of whether smooth solutions to the three-dimensional Navier–Stokes equations persist for all time remains unresolved.

Even today, accurate simulations of turbulent flows lie far beyond the reach of the most advanced supercomputers. In this talk, I will introduce the major hurdles faced by various scientific communities in tackling this grand challenge, with a particular focus on the rigorous mathematical foundations of turbulence—explained in accessible, layman-friendly terms.

L^p-Perspectives on Deterministic and Stochastic Evolution Equations

Robert Denk

Universität Konstanz
Box 193, 78457 Konstanz, Germany
robert.denk@uni-konstanz.de

Nonlinear parabolic partial differential equations can often be studied effectively through the analysis of associated operators on L^p-Sobolev spaces.

In this talk, we describe how techniques from function space theory and harmonic analysis yield fundamental properties of linearized operators, including maximal L^p-regularity and a bounded H^∞-calculus. These tools provide a robust framework for proving well-posedness and regularity for both deterministic and stochastic partial differential equations. We begin with simple examples to illustrate the main concepts and then discuss applications from mathematical physics, such as free boundary problems in fluid mechanics and the stochastic primitive equations.

Flow-Induced Oscillations in Fluid-Structure Interactions

Giovanni P. Galdi

607 Benedum Engineering Hall, University of Pittsburgh
Pittsburgh, PA 15261, USA
galdi@pitt.edu

The flow of a viscous fluid around structures is a fundamental problem that lies at the heart of the broad research area of Fluid-Structure Interactions (FSI). A fundamental aspect of this problem concerns the study of the oscillations (vibrations) induced by the fluid on the structure, when the flow is in a time-periodic regime. An important feature of this interaction is the phenomenon of resonance, which occurs when the frequency of the flow reaches a multiple of one of the natural frequencies of the structure. In fact, it may lead to destructive consequences, as damage or even collapse of the structure. Objective of this talk is to analyze this phenomenon from a rigorous mathematical viewpoint, when the structure is modeled as a spring-mounted rigid body and the fluid is governed by the Navier-Stokes equations.

The Q-Tensor Model for Liquid Crystals with Arbitrary Ratio of Tumbling and Aligning Effects

Amru Hussein

Universität Kassel,
Fachbereich Mathematik, Heinr.-Plett-Straße 40, 34132 Kassel, Germany
ahussein@mathematik.uni-kassel.de

The Beris-Edwards model of nematic liquid crystals couples an equation for the molecular orientation described by the Q-tensor with a Navier-Stokes type equation with an additional non-Newtonian stress caused by the molecular orientation. Both equations contain a parameter measuring the ratio ξ of tumbling and alignment effects. Previous well-posedness results largely vary on the space dimension and constraints on the parameter ξ. Here, we discuss how these constraints can be overcome by methods from quasilinear evolution equations. The key observation is that taking a particular linearization, the linearized operator has a distinguished block structure which implies maximal $L^p - L^2$-regularity based on techniques from sectorial operators, Schur complements and J-symmetry of block operator matrices. Moreover, using extrapolation results for the bounded H^∞-calculus, we can extend this to the $L^p - L^q$-scale for q close to 2.

From the Ocean to Applied Analysis

Peter Korn

Max-Planck Institute for Meteorology
Bundesstraße 53, 20146 Hamburg, Germany
peter.korn@mpimet.mpg.de

The world ocean is at once central to the Earth's climate. It absorbs more than 90% of the excess heat from anthropogenic forcing and roughly a quarter of fossil-fuel CO2 and largely inaccessible to direct observation: the interior is opaque, the overturning circulation evolves on timescales of centuries to millennia, and the available instrumental record samples only a vanishing fraction of the relevant phase space. Quantitative knowledge of the ocean therefore rests, irreducibly, on numerical simulation. This talk surveys what ocean modelling now does, what it cannot yet do, and where applied analysis enters the story. The lecture is dedicated to Matthias Hieber, whose work on the primitive equations has built much of the bridge the talk crosses.

On Existence of a Collapsed Bubble with Surface Tension in Viscous Incompressible Fluids

Yoshikazu Giga

Graduate School of Mathematical Sciences, The University of Tokyo
Komaba 3-8-1, Meguro, Tokyo 153-8914, Japan
labgiga@ms.u-tokyo.ac.jp

We consider a bubble in a viscous incompressible fluid with surface tension in $\mathbb{R}^n$. We give rigorous proof that a bubble collapses in finite time with some initial data. This justifies the existence of a 'micro-jet' which is experimentally observed in a fluid. For the proof, we introduce the δ-wing of a domain, which is a flat manifold not embedded in $\mathbb{R}^n$ but covering the δ-neighborhood of the domain. This talk is based on my recent joint work with one of my former students Z. Gu (Shenzhen University).

A Regularized Interface Method for FSI Problems with Low Regularity Interfaces

Sunčica Čanić

University of California, Berkeley
Berkeley, 94720, CA, USA
canics@berkeley.edu

We introduce a new regularized interface method for proving existence of weak solutions to nonlinear moving boundary problems with low-regularity interfaces. As a benchmark, we study a fluid-poroelastic structure interaction (FPSI) problem coupling the Navier-Stokes equations for an incompressible viscous fluid with the Biot system for a bulk poroelastic medium. The two phases occupy domains of the same spatial dimension, separated by a moving interface defined by the trace of the poroelastic displacement, which exhibits low regularity and strong geometric nonlinearities. Despite its importance in applications, no weak existence theory has been available for this nonlinear moving-domain setting, primarily because the lack of interface regularity precludes even the formulation of a weak solution framework.

To address this gap, we (1) introduce a regularization of the Biot displacement via spatial convolution at scale $\delta > 0$, and (2) modify the weak formulation in a way that preserves energy consistency with the original problem. For each fixed $\delta > 0$, we prove existence of a weak solution to the resulting nonlinear regularized interface problem, and show that in the limit as $\delta \to 0$ the regularized weak solutions recover

classical solutions to the non-regularized problem when such classical solutions exist (weak-classical consistency).

The existence proof for the regularized problem involves inserting a thin plate of thickness $h > 0$ at the interface, applying a time-discretization via a Lie operator splitting scheme, establishing uniform a priori bounds, and employing Aubin-Lions compactness on moving domains. The analysis is particularly involved, partly because the thin plate allows displacements in all spatial directions, which may lead to the formation of certain geometric singularities not present when only scalar (transverse) displacements are considered. Passing to the singular limit $h \to 0$ with uniform-in-h estimates and Aubin–Lions-type compactness arguments yields a regularized interface weak solution. The regularization introduced here is essential to maintain uniform geometric control of the moving interface and to accommodate vector-valued structural displacements.

This is a joint work with Jeffrey Kuan (University of Maryland) and Boris Muha (University of Zagreb, Croatia).

SPDEs for Turbulent Transport

Franco Flandoli

Scuola Normale Superiore
Piazza dei Cavalieri 7, 56126 Pisa, Italy
franco.flandoli@sns.it

Modern fusion plasma devices called Tokamak aim to work in the so-called H-mode regime (High confinement), opposite to the L-mode one (Low confinement). Both of them are turbulent fluid dynamic regimes, for a plasma subject to a very strong magnetic field. After a brief introduction to the topic, the talk will focus on the turbulent heat transport, showing how SPDEs suitably model the problem and allow one to compute the energy confinement time, the quantity of major interest. SPDEs may be crucial also for the understanding of the L-H transition and for the development of anomalous heat transport models; some ideas in this direction will be also mentioned. The research has been performed in the framework of the ERC AdG project NoisyFluid, no. 101053472.

Optimal Mixing in Incompressible Flows

Anna Mazzucato

Penn State University
305 McAllister Building, University Park, PA 16802, USA
alm24@psu.edu

I will survey recent results concerning optimal mixing by incompressible flows from a PDE/geometric analysis perspective and its consequences, such as enhanced and anomalous dissipation.

Free Boundary Problems for the Navier–Stokes Equations in Scaling Critical Spaces

Senjo Shimizu

Department of Mathematics, Graduate School of Science, Kyoto University
Kyoto 606-8502, Japan
shimizu.senjo.5s@kyoto-u.ac.jp

A time-dependent free surface problem for the Navier–Stokes equations which describes the motion of viscous fluid in a domain close to the half-space is considered. We discuss well-posedness of the problem for an initial data in scale invariant critical Besov spaces. Our proof is based on maximal L^1-regularity of the corresponding Stokes problem in the half-space. Utilizing the almost orthogonal properties between the boundary potential and the Littlewood–Paley decomposition, we show maximal L^1-regularity in the Besov and the Lizorkin–Triebel spaces. This is a joint work with Takayoshi Ogawa (Waseda University).

Chasing Regularization by Noise of 3D Navier-Stokes Equations

Antonio Agresti

Department of Mathematics Guido Castelnuovo, Sapienza University of Rome
P.le Aldo Moro 5, Rome
antonio.agresti@uniroma1.it

Global well-posedness of the 3D Navier-Stokes equations (NSEs) is one of the major open problems in modern mathematics. A long-standing conjecture in stochastic fluid dynamics suggests that physically motivated noise can prevent (potential) blow-up of solutions to the 3D NSEs. This phenomenon is often referred to as "regularization by noise". In this talk, I will review recent developments on the topic and discuss the solution to this problem in the case of the 3D NSEs with small hyperviscosity, for which global well-posedness in the deterministic setting remains as open as for the 3D NSEs. An extension of our techniques to the case without hyperviscosity poses new challenges at the intersection of harmonic and stochastic analysis, which I will outline at the end of the talk.

PDEs in Lipschitz Domains

Sylvie Monniaux

Aix-Marseille University
CNRS, I2M UMR7373, Marseille, France
sylvie.monniaux@univ-amu.fr

In this talk, I will present some techniques that are specific to working in non smooth domains: Navier-Stokes equations in Lipschitz domains, Keller-Segel-Navier-Stokes or MHD in Lipschitz of C^1 domains.

Helmholtz-Weyl Decompositon and its Application to the MHD Equations

Hideo Kozono

Department of Mathematics, Faculty of Science and Engineering, Waseda University
Tokyo, 169-8555, Japan
and
Mathematical Research Center for Co-creative Society, Tohoku University
Sendai, 980-8578, Japan
kozono@waseda.jp

In this talk, we show the L^r-Helmholtz-Weyl decompositon in 3D bounded domains. In particular, we bring a focus to characterization of harmonic vector fields. As an application, we prove well-posedness of the magnethydrodynamic equations without any geometric or topological restriction on the domain except smoothness of its boundary. Our result is based on the joint work of Senjo Shimizu (Kyoto) and Taku Yanagisawa (Nara/Waseda).

4 Participants

H. Abels, Universität Regensburg

A. Agresti, Università degli Studi di Roma La Sapienza

H. Amann, Universität Zürich

W. Arendt, Universität Ulm

T. Binz, Princeton University

F. Brandt, UC Berkeley

D. Bresch, Université Savoie Mont-Blanc, Chambéry

S. Čanić, UC Berkeley

R. Danchin, Université Paris-Est-Créteil

G. Del Sarto, TU Darmstadt

R. Denk, Universität Konstanz

J. Escher, Leibniz Universität Hannover

B. Farkas, Bergische Universität Wuppertal

R. Farwig, TU Darmstadt

F. Flandoli, Scuola Normale Superiore, Pisa

P. Galdi, University of Pittsburgh

H. Garcke, Universität Regensburg

A. Gaudin, Universität Duisburg-Essen

M. Giga, The University of Tokyo

Y. Giga, The University of Tokyo

F. Gmeineder, Universität Konstanz

J. Godoy Mesquita, University of Campinas

R. Haller, TU Darmstadt

H. Heck, Bern University of Applied Sciences

M. Hieber, TU Darmstadt

G. Huisken, MFO, Oberwolfach

A. Hussein, Universität Kassel

Y. Kagei, Tokyo Institute of Technology

T. Kashiwabara, The University of Tokyo

B. Khouider, University of Victoria

S. Klaus, MFO, Oberwolfach

R. Klein, FU Berlin

P. Korn, MPI Hamburg

H. Kozono, Waseda University, Tokyo & Tohoku University, Sendai

P. Kunstmann, KIT, Karlsruhe

J. Li, South China Normal University, Guangzhou

M.C. Lopes Filho, Universidade Federal do Rio de Janeiro

J. Lopez-Gomez, Universidad Complutense de Madrid

L. Lorenzi, Università di Parma

M. Lukáčová, Johannes Gutenberg-Universität Mainz

Y. Maekawa, Kyoto University

P. Maremonti, Università degli Studi della Campania Luigi Vanvitelli, Caserta

A. Mazzucato, Penn State University, University Park

E. de Mello Bonotto, Universidade de São Paulo

G. Metafune, Università del Salento, Lecce

S. Modena, Gran Sasso Science Institute, L'Aquila

S. Monniaux, Université d'Aix-Marseille

P. Mucha, University of Warsaw

R. Nagel, Eberhard Karls Universität Tübingen

Š. Nečasová, Czech Academy of Sciences, Prague

H. Nussenzveig, Universidade Federal do Rio de Janeiro

D. Pallara, Università del Salento, Lecce

F. Palma, Università degli Studi della Campania Luigi Vanvitelli, Caserta

R. Racke, Universität Konstanz

J. Rehberg, Weierstraß-Institut für Angewandte Analysis und Stochastik, Berlin

A. Rhandi, Università degli Studi di Salerno

A. Roy, Basque Center for Applied Mathematics, Bilbao

J. Saal, Heinrich-Heine-Universität Düsseldorf

M. Schatz, TU Darmstadt

R. Schnaubelt, KIT, Karlsruhe

E. Schrohe, Leibniz Universität Hannover

S. Shimizu, Kyoto University

G. Simonett, Vanderbilt University, Nashville

C. Stinner, TU Darmstadt

E.S. Titi, University of Cambridge, Texas A&M University, & Weizmann Institute

P. Tolksdorf, KIT, Karlsruhe

C. Tretter, Universität Bern

M. Tucsnak, Université de Bordeaux

K. Urban, Universität Ulm

M. Veraar, TU Delft

V. Vespri, Università di Firenze, Florence

C. Walker, Leibniz Universität Hannover

L. Weis, KIT, Karlsruhe

M. Wilke, Martin-Luther-Universität Halle-Wittenberg

I. Wood, University of Kent

M. Yamamoto, The University of Tokyo

T. Zöchling, TU Darmstadt