Herbert Koch

Academic career

1990	PhD, University of Heidelberg
1988 - 1992	Postdoc, University of Heidelberg
1992 - 1994	Visiting Assistant Professor, Northwestern University, Evanston, IL, USA
1994 - 2000	Postdoc, University of Heidelberg
2000	Habilitation
2000 - 2006	Professor (C4), University of Dortmund
2005 - 2006	Visiting Miller Professor, Mathematical Sciences Research Institute (MSRI), University of California, Berkeley, CA, USA
Since 2006	Professor (W3), University of Bonn

Honours

2005	Miller professorship, Miller Institute, Berkeley, CA, USA

Invited Lectures

2004	International Conference on Harmonic Analysis and Partial Differential Equations, El Escorial, Madrid, Spain
2005	Analyse des Equations aux Dérivées Partielles, Forges-Les-Eaux, France
2017	DiPerna Lecture Berkeley, CA, USA

Research Projects and Activities

DFG Collaborative Research Center SFB 611 “Singular Phenomena and Scaling in Mathematical Models”
Project leader, 2007 - 2012
DFG Collaborative Research Center SFB 1060 “The Mathematics of Emergent Effects”
Project leader, since 2013

Research profile

Partial differential equations provide a ‘language’ for describing phenomena ranging from geometry and analysis, physics and chemistry to engineering and economy. Central themes are the study of local properties of solutions and the passage from local considerations to global conclusions. The local regularity considerations of [1] imply regularity of solutions to the porous medium equation for large time without nondegeneracy conditions on the initial data. Carleman inequalities provide a robust alternative to monotonicity formulas. They provide an essential tool for the study of thin obstacles in the variable coefficient case [2]. Global existence and scattering for dispersive equations and the construction of conserved energies for the Korteweg-de Vries and the cubic nonlinear Schrödinger equation [**?**] are about global consequences of local properties. The self-similar solution to the generalized KdV equations [5] describe the structure of the blow-up.
The local analysis of three phase problems with triple lines of codimension 2 is challenging but it became accessible for the simplest model problems like thin obstacles. A first step consists in the proper linearization, and its connection to Calderón-Zygmund estimates. The quest for a more global understanding of dispersive waves is the driving motivation for many recent questions: Soliton resolution is a vague imprecise conjecture which I want to attack for the Korteweg-de Vries equation with PDE techniques. The Korteweg-de Vries equation is an asymptotic equation for water waves with finite depth. Global existence for small data may be within reach, with a study of the dynamics of the Gross-Pitaeviskii being an intermediate step.

Editorships

- Mathematische Annalen (2006 - 2014)
- Analysis and PDE (since 2008)
- SIAM Journal Mathematical Analysis (since 2012)

Research Area A The cubic nonlinear Schrödinger equation describes interacting nonlinear waves for nonlinear optics and water waves in certain asymptotic regimes. In [**?**] we construct a continuous family of conserved energies leading to uniform in time estimates in a large range of fractional Sobolev and Besov spaces. This construction relies on the Lax pair, without decay assumptions on the initial data, which however would be needed for the inverse scattering machinery.
A partial hodograph transform changes the thin obstacle problem at a regular point of the codimension two free boundary into a degenerate Monge-Ampere type equation modeled after the Baoundi-Grushin operator. In a series of papers we explored this connection and combined it with Carleman estimates to obtain smoothness of the free boundary of codimension two.
Multiple length and frequency scale, and their interaction are behind the estimates of eigenfunctions for Lipschitz coefficients in [6]: For a fixed frequency there is the small dispersive length scale, and the much larger length scale for energy estimates.

Research Area B The flow of gas through a porous medium described by the porous medium equation is a long studied test problem. In [1] we studied smoothness of flat weak solutions, with large time regularity and asymptotics as main consequence, for the first time without regularity or nondegeneracy assumptions on the initial data. With Denzler and McCann [4] we obtained the detailed asymptotics for the fast diffusion equation, again with the suprising geometry of the linearization playing a decisive role.

Supervised theses

Master theses currently: 2
Diplom theses: 4, currently 2
PhD theses: 10, currently 7

Selected PhD students

Adina Guias (2005): “Eine analytische Methode zur Punktereduktion und Flächenrekonstruktion”,
now Teacher, Phoenix Gymnasium
Sebastian Herr (2006): “Well-Posedness Results for Nonlinear Dispersive Equations with Derivative Nonlinearities”,
now Professor, University of Bielefeld
Martin Hadac (2007): “On the Local Well-Posedness of the Kadomtsev-Petviashvili II Equation”,
now in Consulting
Tobias Schottdorf (2013): “Global Existence without decay”,
now working at Cockroach Labs
Clemens Kienzler (2013): “Flat fronts and stability for the porous medium equation”,
now working at McKinsey
Dominik John (2013): “Uniqueness and Stability near Stationary Solutions for the Thin-Film Equation in Multiple Space Dimensions with Small Initial Lipschitz Perturbations”,
now in Consulting
Stefan Steinerberger (2013): “Geometric structures arising from partial differential equations”,
now Assistant Professor, Yale University, CT, USA
Angkana Rüland (2014): “On some rigidity properties in PDEs”,
now leader of Max Planck Research Group at the Max Planck Institute for Mathematics in the Sciences, Leipzig
Habiba Kalantarova (2015): “Local Smoothing and Well-Posedness Results for KP-II Type Equations”,
now Associate Professor, Baku, Azerbaijan

Christian Zillinger (2015): “Linear Inviscid Damping for Monotone Shear Flows, Boundary Effects and Sharp Sobolev Regularity”,
now Postdoc, University of Southern California, Los Angeles, USA

Habilitations

Flavius Guias (2006), now Professor, Fachhochschule Dortmund (University of Applied Sciences and Arts)
Axel Grünrock (2011), now apl. Professor, University of Düsseldorf

Selected publications

[1] Clemens Kienzler, Herbert Koch, and Juan Luis Vazquez. Flatness implies smoothness for solutions of the porous medium equation. *arXiv*, 1609.09048, 2016.
[2] Herbert Koch, Angkana Rüland, and Wenhui Shi. The variable coefficient thin obstacle problem: Carleman inequalities. *Adv. Math.*, 301:820–866, 2016.
[3] Herbert Koch and Daniel Tataru. Conserved energies for cubic nls in 1-d. *arXiv*, 1607.02534, 2016.
[4] Jochen Denzler, Herbert Koch, and Robert J. McCann. Higher-order time asymptotics of fast diffusion in euclidean space: a dynamical systems approach. *Mem. Amer. Math. Soc.*, 234(1101):vi+81, 2015.
[5] Herbert Koch. Self-similar solutions to super-critical gkdv. *Nonlinearity*, 28(3):545–575, 2015.
[6] Herbert Koch, Hart F. Smith, and Daniel Tataru. Sharp L^p bounds on spectral clusters for lipschitz metrics. *Amer. J. Math.*, 136(6):1629–1663, 2014.
[7] Herbert Koch and Tobias Lamm. Geometric flows with rough initial data. *Asian J. Math.*, 16(2):209–235, 2012.
[8] Herbert Koch and Daniel Tataru. Energy and local energy bounds for the 1-d cubic nls equation in $H^{-\frac{1}{4}}$. *Ann. Inst. H. Poincar'e Anal. Non Lin'eaire*, 29(6):955–988, 2012.
[9] Martin Hadac, Sebastian Herr, and Herbert Koch. Well-posedness and scattering for the kp-ii equation in a critical space. *Ann. Inst. H. Poincar'e Anal. Non Lin'eaire*, 26(3):917–941, 2009.
[10] Herbert Koch and Daniel Tataru. Dispersive estimates for principally normal pseudodifferential operators. *Comm. Pure Appl. Math.*, 58(2):217–284, 2005.