Heiko Gimperlein

Leopold-Franzens-Universität Innsbruck
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Research Interests

Partial differential equations and numerical analysis, in particular:

- Pseudodifferential and boundary integral operators, microlocal analysis
- Theoretical numerical analysis of boundary problems
- Applications in engineering, computer science and the natural sciences

Education

Leibniz University Hannover, Hannover/Germany

Ph.D. in Mathematics (2010)
Thesis title: *Topics in singular analysis with applications to numerical analysis and to representation theory.*

Diploma in Mathematics (2006)
Thesis title: *The residue determinant and noncommutative oscillators on R^n.*

Diploma in Physics (2005)
Thesis title: *Disorder and nonequilibrium phenomena in ultracold atomic gases confined to optical lattices.*

Employment

Leopold-Franzens-University Innsbruck, professor (2022 –)

Heriot-Watt University and Maxwell Institute for Mathematical Sciences (2013 – 2022)
assistant professor / associate professor / professor

University of Parma, visiting professor (summer 2022)

University of Paderborn, visiting research professor
(May 2015 – May 2016, April – July 2017, Nov – Dec 2019)

University of Copenhagen, postdoc (July 2010 – July 2013)

Leibniz University Hannover, research assistant (Oct 2006 – June 2010)

Awards

Wissenschaftspreis Hannover 2010 (biennial thesis award of Leibniz University)

Prediploma Award of the Christian Kuhlemann Foundation and Leibniz University

Fellowship of the German National Merit Foundation

Students

Ph.D.: N. Louca, J. Stocek, K. Quaine, R. He and D. Torkington (with A.A. Lacey)

past: G. Estrada-Rodriguez, D. Stark, M. Iqbal (with O. Laghrouche / M.S. Mohamed), C. Özdemir (with E.P. Stephan)

9 M.Sc. students, 1 M.Math. student, 11 B.Sc. students, 8 undergraduate research projects

Extended Research Visits

University of Parma	summer 2022
University of Paderborn	Nov – Dec 2019, April – July 2017, May 2015 – May 2016
Institut Henri Poincaré / Centre Émile Borel, Paris	Oct 2016
TU Wien	June 2016
École Normale Supérieure, Paris	Nov / Dec 2014
Centre de Recerca Matemàtica, Barcelona	June / July 2013
Rutgers, New Brunswick	Nov 2012
Max Planck Institute for Mathematics, Bonn	Aug / Sept 2011
Institut Henri Poincaré / Centre Émile Borel, Paris	June 2009
Mathematical Sciences Research Institute, Berkeley	Sept – Dec 2008
ETH Zürich	June / July 2008

Lecturing Visits

African Institute for Mathematical Sciences, Biriwa	May 2014

Heiko Gimperlein

Invited Talks (since 2010)

More than 50 invited talks at international mathematics and engineering conferences.

More than 45 invited talks in departmental seminars since 2010, e.g. in Bonn, Oxford, Paris, Stanford.

Grants

Danish Science Foundation FNU research grant (2010–2012)

EPSRC Impact Acceleration Account award (2016–2017)

Numerous smaller grants for conference organization, Ph.D. positions and research beyond departmental resources (e.g. Clay Institute, MSRI, London Math. Society)

Conference Organization

International conferences:

From Individual to Collective Behaviour in Biological and Robotic Systems
(International Centre for Mathematical Sciences, Edinburgh, 2022)

Convex Integration and Nonlinear Partial Differential Equations
(International Centre for Mathematical Sciences, Edinburgh, 2021)

Models for Energetic Materials
(virtual workshop, 2021)

Mathematical Modelling of Energetic Materials
(International Centre for Mathematical Sciences, Edinburgh, 2019)

Magnitude 2019: Analysis, Category Theory, Applications
(Edinburgh, 2019)

Recent Advances in Enriched Finite and Boundary Element Methods
(minisymposium, European Conference on Computational Mechanics, Glasgow, 2018)

Prediction and Data Assimilation for Nonlocal Diffusions
(International Centre for Mathematical Sciences, Edinburgh, 2018)

Nonlinear Analysis and the Physical and Biological Sciences
(International Centre for Mathematical Sciences, Edinburgh, 2018)

50th Anniversary Meeting of the North British Functional Analysis Seminar
(International Centre for Mathematical Sciences, Edinburgh, 2018)

Edinburgh Mathematical Society – Catalan Mathematical Society Joint Meeting
(International Centre for Mathematical Sciences, Edinburgh, 2017)

Advances in Structural Engineering and Civil Engineering Materials
(National Telford Institute, Edinburgh, 2017)

Numerical Methods for Interface and Multiphysics Problems
(minisymposium, 27th biennial Numerical Analysis conference, Strathclyde, 2017)

Recent Advances in Enriched Finite and Boundary Element Methods
(minisymposium, 15th MAFELAP conference, London, 2016)

Boundary Integral Equations – Analysis and Computation
(International Centre for Mathematical Sciences, Edinburgh, 2014)

Graduate schools:

1st, 2nd and 3rd Maxwell Institute Graduate School on Evolution Equations
(International Centre for Mathematical Sciences, Edinburgh, 2014, 2015 resp. 2017)

Workshop / Ph.D. course on *Spectral Theory* (Copenhagen, 2012)

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Activities and Service

Head of Unit for Engineering Mathematics (2022 –)

Organizer of Analysis seminar (2014 – 2015, 2016 – 2022)

Maxwell Mini-Symposia Analysis and its Applications, resp. PDE (Feb 2015 – 2022)

Theme head for Analysis in Scottish Mathematical Sciences Training Centre (2017 – 2022)

Department representative on
North British Functional Analysis Seminar (2014 – 2021),
Edinburgh Mathematical Society General Committee (2013 – 2016).

Acting Director for Training of the EPSRC Centre for Doctoral Training MIGSAA (2017, deputy 2015 – 2016)

Member of Mathematics Undergraduate Board of Studies (2014 – 2015)

Teaching

Mathematics:

M.Sc. course *Numerical Methods for Differential & Integral Equations* (Parma)	Spring 2022
B.Sc. course *Mathematics for Engineers and Scientists D*	Spring 2021
Ph.D. course *Variational Methods for PDEs* (with D. Coutand)	Spring 2021
M.Sc. course *Research and Industry Topics*	Spring 2020
Ph.D. course *Variational Methods for PDEs* (with J.M. Ball)	Spring 2019
Ph.D. course *Numerical Analysis*	Spring 2018 / 20
Ph.D. course *Harmonic Analysis and Function Spaces* (broadcast via SMSTC)	Spring 2017
B.Sc. course *Mathematics for Direct Entrants* (for students starting in Year 2)	Fall 2016
Ph.D. short course *Interface and Contact Problems* (TU Wien)	June 2016
Ph.D. course *Functional Analysis* (broadcast, SMSTC)	Spring 2015/17/18/19/20/21
Ph.D. course *Elliptic and Parabolic PDEs* (broadcast, SMSTC)	Spring 2015/17/18/19/20
B.Sc. course *Numerical Analysis A*	Spring 2014 / 15
M.Sc./Ph.D. course *Pseudodifferential Operators and Spectral Theory*	Fall/Winter 2011
M.Sc. course *Differential Operators and Function Spaces II*	Summer 2011 / 12
B.Sc. course *Introduction to Partial Differential Equations*	Fall 2010

Preprints

preprints and publications are available at www.macs.hw.ac.uk/~hg94

with A. Aimi, G. Di Credico, E. P. Stephan, *Higher-order time domain boundary elements for elastodynamics – graded meshes and hp-versions.*

with M. Goffeng, N. Louca, *The magnitude and spectral geometry.*
(+ invited blog post at n-Category Cafe, https://golem.ph.utexas.edu/category)

with M. Goffeng, N. Louca, *Semiclassical analysis of a nonlocal boundary value problem related to magnitude.*

with R. He, A. A. Lacey, *Quenching for a semilinear wave equation for MEMS.*

with G. Estrada-Rodriguez, J. Stocek, *Nonlocal interface problems: Modelling, regularity, finite element approximation.*

with E. P. Stephan, *Adaptive FE–BE coupling for strongly nonlinear transmission problems with friction II.*

Publications

with B. Krötz, J. J. Kuit and H. Schlichtkrull, *A Paley-Wiener theorem for Harish-Chandra modules,* Cambridge Journal of Mathematics (2022).

with M. Goffeng, *The Willmore energy and the magnitude of Euclidean domains*, Proceedings of the American Mathematical Society (2022).

with M. Dragone, S. Duncan, G. Estrada-Rodriguez, J. Stocek, P. Vargas, *Efficient quantitative assessment of robotic swarms: Coverage and targeting Levy strategies,* Bioinspiration & Biomimetics 17 (2022), 036006.

with J. Stocek, C. Urzua-Torres, *Optimal operator preconditioning for pseudodifferential boundary problems,* Numerische Mathematik 148 (2021), 1 – 41.

with M. Goffeng, *On the magnitude function of domains in Euclidean space*, American Journal of Mathematics 143 (2021), 939 – 967.
(+ 4 invited blog posts at n-Category Cafe, https://golem.ph.utexas.edu/category)

with B. Krötz, *On Sobolev norms for Lie group representations*, Journal of Functional Analysis 280 (2021), 108882.

with S. Bernardi, G. Estrada-Rodriguez, K. J. Painter, *Macroscopic descriptions of follower-leader systems*, Kinetic and Related Models 14 (2021), 981 – 1002.

with M. Maischak and E. P. Stephan, *FE–BE coupling for a transmission problem involving microstructure*, Journal of Applied and Numerical Optimization 3 (2021), 315 – 331.

with C. Özdemir, D. Stark and E. P. Stephan, *A residual a posteriori error estimate for the time-domain boundary element method*, Numerische Mathematik 146 (2020), 239 – 280.

with G. Estrada-Rodriguez and E. Estrada, *Metaplex networks: Influence of the exo-endo structure of complex systems on diffusion,* SIAM Review 62 (2020), 617 – 645, Research Spotlights.

with M. Iqbal, O. Laghrouche, M. S. Mohamed and D. Stark, *Local adaptive q-enrichments and generalized finite elements for transient heat diffusion problems,* Computer Methods in Applied Mechanics and Engineering 372 (2020), 113359.

with G. Estrada-Rodriguez, *Interacting particles with Levy strategies: limits of transport equations for swarm robotic systems,* SIAM Journal on Applied Mathematics 80 (2020), 476 – 498.

with K. Alam, M. Iqbal, O. Laghrouche and M. S. Mohamed, *A residual a posteriori error estimate for partition of unity finite elements for three-dimensional transient heat diffusion problems using multiple global enrichment functions,* International Journal for Numerical Methods in Engineering 121 (2020), 2727 – 2746.

with C. Özdemir and E. P. Stephan, *A time-dependent FEM-BEM coupling method for fluid-structure interaction in 3d*, Applied Numerical Mathematics 152 (2020), 49 – 65.

with K. Alam, M. Iqbal, M. S. Mohamed and O. Laghrouche, *Effect of enrichment functions on GFEM solutions of time-dependent conduction heat transfer problems*, Applied Mathematical Modelling 85 (2020), 89 – 106.

with C. Özdemir, D. Stark and E. P. Stephan, *hp-version time domain boundary elements for the wave equation on quasi-uniform meshes,* Computer Methods in Applied Mechanics and Engineering 356 (2019), 145 – 174.

with J. Stocek, *Space-time adaptive finite elements for nonlocal parabolic variational inequalities,* Computer Methods in Applied Mechanics and Engineering 352 (2019), 137-171.

with G. Estrada-Rodriguez, K. J. Painter and J. Stocek, *Space-time fractional diffusion in cell movement models with delay,* Mathematical Models and Methods in Applied Sciences 29 (2019), 65 – 88.

with M. Goffeng, *Commutator estimates on contact manifolds and applications*, Journal of Noncommutative Geometry 13 (2019), 363 – 406.

with D. Stark, *Algorithmic aspects of enriched time domain boundary element methods*, Engineering Analysis with Boundary Elements 100 (2019), 118 – 124.

with F. Meyer, C. Özdemir, D. Stark and E. P. Stephan, *Boundary elements with mesh refinements for the wave equation*, Numerische Mathematik 139 (2018), 867 – 912.

with G. Estrada-Rodriguez and K. J. Painter, *Derivation of fractional Patlak-Keller-Segel equations for chemotactic superdiffusion,* SIAM Journal on Applied Mathematics 78 (2018), 1155 – 1173.

with F. Meyer, C. Özdemir and E. P. Stephan, *Time domain boundary elements for dynamic contact problems*, Computer Methods in Applied Mechanics and Engineering 333 (2018), 147 – 175.

with C. Özdemir and E. P. Stephan, *Time-domain boundary element methods for the Neumann problem: Error estimates and acoustic problems,* Journal of Computational Mathematics 36 (2018), 70 – 89, special issue.

with D. Stark, *On a preconditioner for time domain boundary element methods,* Engineering Analysis with Boundary Elements 96 (2018), 109 – 114.

with M. Goffeng, *Nonclassical spectral asymptotics and Dixmier traces: From circles to contact manifolds*, Forum of Mathematics, Sigma 5 (2017), e3, 57 pages.

with M. Iqbal, M. S. Mohamed and O. Laghrouche, *An a posteriori estimate for the generalized finite element method for transient heat diffusion problems,* International Journal for Numerical Methods in Engineering 110 (2017), 1103 – 1118.

with M. Maischak and E. P. Stephan, *Adaptive time-domain boundary element methods and engineering applications*, Journal of Integral Equations and Applications 29 (2017), 75 – 105, invited review article.

with L. Banz, A. Issaoui and E. P. Stephan, *Stabilized mixed hp-BEM for frictional contact problems in linear elasticity*, Numerische Mathematik 135 (2017), 217 – 263.

with B. Krötz and H. Schlichtkrull, *Corrigendum – Analytic representation theory of Lie groups: General theory and analytic globalizations of Harish-Chandra modules,* Compositio Mathematica 153 (2017), 214 – 217.

with A. Waters, *A deterministic optimal design problem for the heat equation*, SIAM Journal on Control and Optimization 55 (2017), 51 – 69.

with C. Dappiaggi, S. Murro and A. Schenkel, *Wavefront sets and polarizations on supermanifolds*, Journal of Mathematical Physics 58 (2017), 023504, 16 pages.

with Z. Nezhi and E. P. Stephan, *A priori error estimates for a time-dependent boundary element method for the acoustic wave equation in a half-space*, Mathematical Methods in the Applied Sciences 40 (2017), 448 – 462, special issue.

with Q. T. Le Gia, M. Maischak and E. P. Stephan, *Solving approximate cloaking problems using finite element methods*, ANZIAM Journal 58 (2017), C162 – C174,proceedings CTAC.

with L. Banz, Z. Nezhi and E. P. Stephan, *Time-domain BEM for sound radiation of tires,* Computational Mechanics 58 (2016), 45 – 57.

with A. Waters, *Stability analysis in magnetic resonance elastography II*, Journal of Mathematical Analysis and Applications 434 (2016), 1801 – 1812.

with A. Costea and E. P. Stephan, *A Nash–Hörmander iteration and boundary elements for the Molodensky problem,* Numerische Mathematik 127 (2014), 1 – 34.

with G. Grubb, *Heat kernel estimates for pseudodifferential operators, fractional Laplacians and Dirichlet-to-Neumann operators,* Journal of Evolution Equations 14 (2014), 49 – 83.

with L. Banz, A. Costea and E. P. Stephan, *Numerical simulations for the non-linear Molodensky problem*, Proceedings of the European Geosciences Union General Assembly 2013, Studia geophysica et geodaetica 58 (2014), 489 – 504.

with B. Krötz and C. Lienau, *Analytic factorization of Lie group representations*, Journal of Functional Analysis 262 (2012), 667 – 681.

with B. Krötz and H. Schlichtkrull, *Analytic representation theory of Lie groups: General theory and analytic globalizations of Harish-Chandra modules,* Compositio Mathematica 147 (2011), 1581 – 1607.

with M. Maischak, E. Schrohe and E. P. Stephan, *Adaptive FE–BE coupling for strongly nonlinear transmission problems with Coulomb friction*, Numerische Mathematik 117 (2011), 307 – 332.

with B. Krötz and H. Schlichtkrull, *Analytic globalizations of Harish-Chandra modules*, Oberwolfach Reports 7 (2010), 3050 – 3052, conference proceedings.

Introduction to hyperbolic billiards, Oberwolfach Reports 7 (2010), 961 – 964, conference proceedings.

with M. Maischak, E. Schrohe and E. P. Stephan, *A finite element / boundary element coupling method for strongly nonlinear transmission problems with contact,* Oberwolfach Reports 5 (2008), 2077 – 2080, conference proceedings.

with S. Wessel, J. Schmiedmayer and L. Santos, *Random on-site interactions versus random potential in ultracold atoms in optical lattices,* Applied Physics B 82 (2006), 217 – 224.

with S. Wessel, J. Schmiedmayer and L. Santos, *Ultracold atoms in optical lattices with random on-site interactions*, Physical Review Letters 95 (2005), 170401 / 1 – 4.

Engineering Conferences

with K. Quaine, *Space-Time Enriched Finite Elements for Transient Wave and Elastic Problems*, 29th Conference of the UK Association for Computational Mechanics (2022).

with K. Quaine, *Space-Time Enriched Finite Elements for Transient Wave Problems*, 28th Conference of the UK Association for Computational Mechanics (2021).

with M. Iqbal, K. Christodoulou, M. S. Mohamed, O. Laghrouche. *High-order finite elements for efficient solution of transient heat diffusion problems with sharp thermal gradients*, 28th Conference of the UK Association for Computational Mechanics (2021).

Boundary element methods for acoustic simulations in the time domain, 23rd International Congress on Acoustics (2019).

with D. Stark, *Boundary elements and mesh refinements for the wave equation*, 25th Conference of the UK Association for Computational Mechanics (2017).

with G. Estrada-Rodriguez, *Generalized finite elements for blow-up solutions to reaction-diffusion equations*, 25th Conference of the UK Association for Computational Mechanics (2017).

with D. Stark, *A partition of unity boundary element method for transient wave propagation*, 24th Conference of the Association for Computational Mechanics in Engineering (2016).

with M. Iqbal, M. S. Mohamed and O. Laghrouche, *Solution of three dimensional heat diffusion problems using an enriched finite element method*, 24th Conference of the UK Association for Computational Mechanics in Engineering (2016).

with M. Iqbal, M. S. Mohamed and O. Laghrouche, *A posteriori estimate for the partition of unity method for transient heat diffusion problems*, 23rd Conference of the UK Association for Computational Mechanics in Engineering (2015).