

**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**

Maxwell Institute for Mathematical Sciences and Heriot–Watt University, Edinburgh

Associate professor / Reader (2016 – )

Assistant professor / Lecturer (2013 – 2016, permanent)

Visiting research professor, University of Paderborn

(May 2015 – May 2016, April – July 2017, Nov – Dec 2019)

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

Research assistant, Leibniz University Hannover (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. Stoeck, 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)

5 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

## Invited Talks (since 2010)

More than 45 invited talks at international mathematics and engineering conferences.  
More than 40 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)

*50<sup>th</sup> 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, 27<sup>th</sup> biennial Numerical Analysis conference, Strathclyde, 2017)

*Recent Advances in Enriched Finite and Boundary Element Methods*  
(minisymposium, 15<sup>th</sup> MAFELAP conference, London, 2016)

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

*Graduate schools:*

*1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> 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)

## Activities and Service

Organizer of Analysis seminar (2014 – 2015, since 2016)  
Maxwell Mini-Symposia Analysis and its Applications, resp. PDE (since Feb 2015)  
Theme head for pure/applied analysis in Scottish Mathematical Sciences Training Centre  
Department representative on  
North British Functional Analysis Seminar (since June 2014),  
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 <i>Research and Industry Topics</i>	Spring 2020
Ph.D. course <i>Variational Methods for PDEs</i> (with J.M. Ball)	Spring 2019
Ph.D. course <i>Numerical Analysis</i>	Spring 2018 / 20
Ph.D. course <i>Harmonic Analysis and Function Spaces</i> (broadcast via SMSTC)	Spring 2017
B.Sc. course <i>Mathematics for Direct Entrants</i> (for students starting in Year 2)	Fall 2016
Ph.D. short course <i>Interface and Contact Problems</i> (TU Wien)	June 2016
Ph.D. course <i>Pure Analysis 2</i> (1/3 of course, broadcast, SMSTC)	Spring 2015/17/18/19/20
Ph.D. course <i>Applied Analysis and PDEs 2</i> (broadcast, SMSTC)	Spring 2015/17/18/19/20
B.Sc. course <i>Numerical Analysis A</i>	Spring 2014 / 15
M.Sc./Ph.D. course <i>Pseudodifferential Operators and Spectral Theory</i>	Fall/Winter 2011
M.Sc. course <i>Differential Operators and Function Spaces II</i>	Summer 2011 / 12
B.Sc. course <i>Introduction to Partial Differential Equations</i>	Fall 2010

## Preprints

*preprints and publications are available at [www.macs.hw.ac.uk/~hg94](http://www.macs.hw.ac.uk/~hg94)*

with S. Bernardi, G. Estrada-Rodriguez, K. J. Painter, *Macroscopic descriptions of follower-leader systems.*

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

with M. Dragone, S. Duncan, G. Estrada-Rodriguez, J. Stoczek, *Efficient quantitative assessment of robotic swarms: Coverage and targeting Levy strategies.*

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

with B. Krötz, J. J. Kuit and H. Schlichtkrull, *A Paley-Wiener theorem for Harish-Chandra modules.*

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

## Publications

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

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 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 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. Stoczek, *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. Stoczek, *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 Problems*, 28<sup>th</sup> 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*, 28<sup>th</sup> Conference of the UK Association for Computational Mechanics (2021).

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

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

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

with D. Stark, *A partition of unity boundary element method for transient wave propagation*, 24<sup>th</sup> 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*, 24<sup>th</sup> 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*, 23<sup>rd</sup> Conference of the UK Association for Computational Mechanics in Engineering (2015).