

GUIDO KANSCHAT

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Department of Mathematics

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1 EDUCATION2004 *Habilitation and venia legendi*, Mathematics, University of Heidelberg, Germany1996 *Doctor rer. nat.* (PhD in Science), University of Heidelberg, Germany1992 *Diplom*, Mathematics, University of Bonn, Germany**2 APPOINTMENTS**

2009–curr. Associate Professor, Texas A&M University

2006–2009 Assistant Professor, Texas A&M University

2005–2006 Research Associate (*Wiss. Ang.*), Department of Applied Mathematics, University of Heidelberg, Germany2000–2005 Assistant Professor (*Wiss. Assistent*), Dept. Appl. Math., Univ. Heidelberg, Germany

1999–2000 Visiting Assistant Professor, School of Mathematics, University of Minnesota

1999 Assistant Professor, Dept. Appl. Math., Univ. Heidelberg, Germany

1995–1999 Research Associate, IWR, Univ. Heidelberg, Germany

1986–1989 Software developer, Siempelkamp Engine Construction, Krefeld, Germany (part time)

3 GRANTS AND AWARDS

2009 KAUST Innovation Award, with R. Korty and D. Thomas

2008 BIRS Conference on Nonstandard Finite Element Methods in Computational Fluid Dynamics, with P. Mineev (U. Alberta) and J.-L. Guermond, 2010

2009 NSF-CBMS: Regional Conference on Adaptive Finite Element Methods, PI, with Wolfgang Bangerth (TAMU)

2008–2010 NSF(DMS): Tuning-free adaptive multilevel Discontinuous Galerkin methods for Maxwell's equations, PI, collaborative research with R. Hoppe (U. Houston) and T. Warburton (Rice U.)

2008–2012 King Abdullah University of Science and Technology Global Research Partnership Center "Institute for Applied Mathematics and Computer Science", investigator, (PI: Jim Calvin)

2007 The J. H. Wilkinson Prize for Numerical Software, with W. Bangerth and R. Hartmann

2007–2011 NSF-DNDO: ARI-LA: A Framework for Developing Novel Detection Systems Focused on Interdicting Shielded HEU, investigator (PI: Warren Miller)

2007–2009 NSF-DMS: Discontinuous Galerkin Methods for PDEs with Heterogeneous Coefficients, co-PI, with Jean-Luc Guermond (TAMU), PI, and Raytcho Lazarov (TAMU)

2006 Deal.II becomes part of the SPEC CPU2006 Benchmark

2000–2003 DFG *Schwerpunktprogramm ANumE*, co-Pi, Rolf Rannacher, PI, 2000–20031999 DFG *Habilitationsstipendium* (postdoctoral scholarship), 5 months

1992–1995 DFG Graduate Scholarship

4 GRANT PROPOSALS

- NSF-CMG: Multi-scale modeling and simulation of coastal dynamics in tsunami waves, PI, with A. Bonito (TAMU) and R. Weiss (TAMU), 2009
- BSF: Low cost high resolution radiative transfer in molecular dominated atmospheres, with G. Shaviv (Technion, Haifa) and N. Shaviv (Hebrew University, Jerusalem), 2008, rejected
- DOE: Quality-Engineered Parallel Software for Solving the Neutron Transport Equation with Error Estimation Capability for Propagating Uncertainties and Sensitivities in Modeling Novel Gen IV Reactor Concepts. PI: Y. Azmi (Penn. State), Co-PIs: D. Keyes (Columbia), J. Brannick, J. Xu, L. Zikatanov (Penn State), K. Clarno (ORNL), G. Kanschat, J. Ragusa (TAMU), 2007, rejected
- NSF-CBMS: Regional Conference on Adaptive Finite Element Methods, with Wolfgang Bangerth (TAMU) as co-PI, 2007, rejected
- NSF(DMS): Adaptive Discontinuous Galerkin Methods for Time-Dependent Incompressible Flow Problems, PI with Wolfgang Bangerth (TAMU) as co-PI, 2006, rejected

5 CONFERENCES AND MINISYMPOSIA (ORGANIZATION)

- BIRS Workshop on Nonstandard Finite Element Methods in Computational Fluid Dynamics, with P. Mineev (U. Alberta) and J.-L. Guermond, 2010
- ISC Workshop on Radiation simulation, College Station, with S. Nasiri, J. Ragusa, 2008
- International Conference on Modeling, Simulation and Optimization of Complex Processes in honor of the 60th birthdays of H. G. Bock and R. Rannacher, Heidelberg, with M. Braack, E. Kostina, J. Schloeder, 2008
- Minisymposium on fast solvers for saddle-point problems with applications in fluid dynamics at ICIAM 07 with M. Olshanskii, 2007
- Minisymposium on high-level software for the numerical solution of partial differential equations at ICIAM 07 with W. Bangerth, R. Kirby, 2007
- First international deal.II user workshop, 2006
- RadConf, interdisciplinary workshop on numerical methods for radiative transfer problems with R. Rannacher, R. Wehrse and E. Meinköhn, 2003
- Minisymposium on discontinuous Galerkin methods at “ENUMATH 01” with E. Süli, 2001
- International conference “ENUMATH 97” with H. G. Bock, R. Rannacher, 1997
- Workshop “Adaptive Finite Element Methods” with Ch. Führer, R. Rannacher, 1995
- Workshop “Natur-Wissenschaft”, modeling in environmental physics with R. Eils, J. Jäger, 1994

6 UNIVERSITY SERVICES

- Liaison of the Institute for Applied Mathematics and Computational Science at Texas A&M University to the Scientific Computing and Imaging Institute at the University of Utah, 2009–
- Texas A&M System Task Force on Export Control Policies, committee on employees and visitors, 2009
- Member executive committee of the faculty senate, 2009–
- Member of the search committee for the Vice President and Associate Provost for Diversity, 2009
- Caucus leader of the College of Science in the faculty senate, since 2008
- Treasurer GLBT professional network, since 2008
- Member of the faculty senate and its committees on research and diversity, since 2007
- Aggie Allies member, since 2007
- Member of the IWR Parallel Computer Committee, U. Heidelberg, 2005–2006
- Member of the Selection Committee, Graduate School for Scientific Computing of the IWR, Heidelberg, 2005
- Head of the Applied Mathematics Student Computer Pool, U. Heidelberg, 2000–2006
- Head of System Administration, AG Numerik, Heidelberg, U. Heidelberg, 1999–2006.

7 REFEREE SERVICES

7.1 JOURNALS

ACM Trans. Math. Software, Comm. Comput. Phys., Comm. Numer. Methods Engrg., Comput. Meth. Appl. Mech. Engrg., Concurrency and Computation: Practice and Experience, IMA J. Numer. Anal., Int. J. Numer. Methods Fluids, J. Comput. Appl. Math., J. Numer. Math., J. Sci. Comput., Math. Comput., M²AN, M³AS, Numer. Math., SIAM J. Numer. Anal., SIAM J. Sci. Comput.

7.2 AGENCIES

National Science Foundation, Deutsche Forschungsgemeinschaft (German Research Foundation), Swiss National Science Foundation

8 STUDENT THESES

8.1 THESIS ADVISOR

- 2 *Diplom*, Univ. Heidelberg (master): Ch. Laux (2006), B. Janssen (2007)

8.2 THESIS CO-ADVISOR (UNIV. HEIDELBERG)

- 2 PhD: H. Hesse (2008)
- 4 *Diplom* (master): W. Bangerth (1999), R. Hartmann (1999), B. Lienert (2004), A. Wild (2001)
- 2 *Staatsexamen* (bachelor): A. Kürbs (1998), I. Krause (2003)

8.3 EXTERNAL REFEREE

- Lars Pesch, PhD, University of Twente, The Netherlands, 2007
- J. J. Sudirham, PhD, University of Twente, The Netherlands, 2005

8.4 COMMITTEES AT A&M

- Jaehun Lee, MS in PETE
- Kalpana Kappagantula, MS in MEEN
- Chang Gyu Kim, MS in INEN
- Yaqi Wang, PHD in NUEN
- Ni Zhen, MS in NUEN
- James R. Newlin, MEN in CVEN
- Jarrod D. Edwards, PHD in NUEN

9 COLLABORATORS

- B. Ayuso, Universidad Autónoma de Madrid, Spain
- W. Bangerth, Texas A&M University
- B. Cockburn, University of Minnesota
- J. Gopalakrishnan, University of Florida
- R. Hartmann, DLR, Braunschweig, Germany
- H. K. Hesse, Universität Heidelberg, Germany
- R. H. W. Hoppe, University of Houston
- I. Hoteit, King Abdullah University of Science and Technology, Saudi Arabia
- R. Korty, Texas A&M University
- E. Meinköhn, Universität Heidelberg, Germany
- I. Perugia, Università di Pavia, Italy
- R. Rannacher, Universität Heidelberg, Germany
- S. Richling, Institut d' Astrophysique de Paris, France
- D. Schötzau, University of British Columbia, Vancouver, Canada
- Ch. Schwab, ETH Zürich, Switzerland
- F.-T. Suttmeier, Universität Siegen, Germany
- T. Warburton, Rice University, Houston
- R. Wehrse, Universität Heidelberg, Germany
- S. Zedler, Texas A&M University

10 INVITED PRESENTATIONS

2009

- Universität Kiel (1 week), Germany
- ENUMATH 2009, Uppsala (minisymposium)
- MAFELAP 2009, London (2 minisymposia)
- University of British Columbia, Vancouver
- Simon Fraser University, Vancouver

2008

- Rensselaer Polytechnic Institute, Troy
- Fraunhofer Institut Kaiserslautern, Germany
- RWTH Aachen, Germany
- Sandia National Lab, Albuquerque
- Virginia Tech, Blacksburg

2007

- BIRS Workshop on DG, Banff
- University of Alberta, Edmonton
- ICIAM07, Zürich, Switzerland (2 minisymposia)
- 3rd Scientific Computing Seminar, Kiel
- Universität Göttingen
- Universität Karlsruhe
- Universität Heidelberg
- Int. Conf. of Theor. and Numer. Fluid Mechanics III, Vancouver
- University of Texas, Austin
- Rice University, Houston

2006

- Max-Planck-Institut Leipzig
- Texas A&M University, College Station

2005

- McGill University, Montreal
- Universität Erlangen
- Universität Siegen
- University of Delaware
- Nanyang Technical University, Singapore
- University of British Columbia, Vancouver
- University of South Carolina (1 month)
- SIAM SEAS Meeting, Charleston (Minisymposium)
- University of Minnesota
- Technische Universität Braunschweig
- Universiteit Twente, Enschede
- Texas A&M University (2 weeks), College Station
- University of Houston
- The University of Reading
- Universität Kiel

- Universität Duisburg

2004

- University of Florida, Gainesville
- Universität Siegen
- Universität Göttingen
- ETH Zürich
- Universität Ulm
- ICOSAHOM04, Providence (Minisymposium)

2003

- Army High Performance Computing Research Center, Minneapolis
- ENUMATH03, Prague (Minisymposium)
- MIT Conference (Minisymposium)

2002

- Technische Universität Dresden
- Mathematisches Forschungsinstitut Oberwolfach
- Università di Pavia
- University of Minnesota

2001

- Chalmers Tekniska Högskola, Göteborg
- University of Minnesota, Minneapolis
- Rensselaer Polytechnic Institute, Troy
- ENUMATH01, Ischia Porto (Minisymposium)
- NUMDIFF 10, Halle (Minisymposium)

2000

- Colorado State University, Fort Collins

1998

- Institut Mittag-Leffler (2 weeks), Stockholm

1997

- Institute of Mathematics and its Application, Minneapolis (1 month)
- National Center for Supercomputer Applications (2 weeks), Urbana-Champaign
- Centre de Recherche en Calcul Appliqué, Montreal
- ETH Zürich

1996

- Universität des Saarlandes, Saarbrücken
- Universität Paderborn
- Australian National University (1 week), Canberra

- University of Sydney
- Zentrum für Interdisziplinäre Forschung, Universität Bielefeld
- Univerzita Karlova, Praha

1994

- Technische Universität Braunschweig
- Universität Paderborn

11 TEACHING RECORD

Fall 08	Differential Equations, 2 sections (MATH 308, Texas A&M)
Spring 08	Linear Algebra and Vector Calculus (MATH 601, Texas A&M)
Fall 07	Differential Equations (MATH 308, Texas A&M)
Spring 07	Partial Differential Equations (MATH 602, Texas A&M)
Fall 06	Numerical Analysis (MATH 417, Texas A&M)
Winter 05/06	Finite elements with applications (course for PhD students in science) (U. Heidelberg)
Summer 05	Numerical Methods for Flow Problems (U. Heidelberg)
Winter 04/05	Numerical Analysis II (Partial Differential Equations) (U. Heidelberg)
Summer 04	C++ programming for numerical applications (U. Heidelberg)
Winter 03/04	C++ programming for numerical applications (U. Heidelberg)
Summer 03	C++ programming for numerical applications (U. Heidelberg)
Winter 02/03	C++ programming for numerical applications (U. Heidelberg)
Summer 02	C++ programming for numerical applications (U. Heidelberg)
Winter 01/02	C++ programming for numerical applications (U. Heidelberg)
Summer 2001	C++ programming for numerical applications (U. Heidelberg)
Winter 00/01	Iterative Solvers for Sparse Linear Systems (U. Heidelberg)
Spring 2000	Numerical Methods for Partial Differential Equations II (University of Minnesota)
Fall 1999	Numerical Methods for Partial Differential Equations I (University of Minnesota)
Summer 1999	Practical Introduction to object-oriented finite element software (U. Heidelberg)
Summer 1998	The Finite Element Method (advanced course) (U. Heidelberg)
Summer 1998	Practical Introduction to object-oriented finite element software (U. Heidelberg)

12 PUBLICATIONS

PAPERS IN REFEREED JOURNALS

- [1] B. Cockburn, G. Kanschat, and D. Schötzau. An equal-order DG method for the incompressible Navier-Stokes equations. *J. Sci. Comput.*, 40(1–3):188–210, 2009.
- [2] G. Kanschat and D. Schötzau. Energy norm a-posteriori error estimation for divergence-free discontinuous Galerkin approximations of the Navier-Stokes equations. *Int. J. Numer. Methods Fluids*, 57(9):1093–1113, 2008.
- [3] G. Kanschat. Robust smoothers for high order discontinuous Galerkin discretizations of advection-diffusion problems. *J. Comput. Appl. Math.*, 218:53–60, 2008.
- [4] G. Kanschat. Divergence-free discontinuous Galerkin schemes for the Stokes equations and the MAC scheme. *Int. J. Numer. Methods Fluids*, 56(7):941–950, 2008.
- [5] R. H. W. Hoppe, G. Kanschat, and T. Warburton. Convergence analysis of an adaptive interior penalty discontinuous Galerkin method. *SIAM J. Numer. Anal.*, 47(1):534–550, 2008. published online.
- [6] B. Cockburn, G. Kanschat, and D. Schötzau. A note on discontinuous Galerkin divergence-free solutions of the Navier-Stokes equations. *J. Sci. Comput.*, 31(1–2):61–73, 2007.
- [7] W. Bangerth, R. Hartmann, and G. Kanschat. deal.II — a general purpose object oriented finite element library. *ACM Trans. Math. Softw.*, 33(4), 2007.
- [8] G. Kanschat. Block preconditioners for LDG discretizations of linear incompressible flow problems. *J. Sci. Comput.*, 22(1):381–394, 2005.
- [9] B. Cockburn, G. Kanschat, and D. Schötzau. A locally conservative LDG method for the incompressible Navier-Stokes equations. *Math. Comput.*, 74:1067–1095, 2005.
- [10] B. Cockburn, G. Kanschat, and D. Schötzau. The local discontinuous Galerkin method for linear incompressible fluid flow: A review. *Comput. & Fluids*, 34(4–5):491–506, 2005.
- [11] G. Kanschat. Multi-level methods for discontinuous Galerkin FEM on locally refined meshes. *Comput. & Struct.*, 82(28):2437–2445, 2004.
- [12] G. Kanschat. Preconditioning methods for local discontinuous Galerkin discretizations. *SIAM J. Sci. Comput.*, 25(3):815–831, 2003.
- [13] J. Gopalakrishnan and G. Kanschat. A multilevel discontinuous Galerkin method. *Numer. Math.*, 95(3):527–550, 2003.
- [14] B. Cockburn, G. Kanschat, and D. Schötzau. The local discontinuous Galerkin method for the Oseen equations. *Math. Comput.*, 73(246):569–593, 2003.
- [15] G. Kanschat and R. Rannacher. Local error analysis of the interior penalty discontinuous Galerkin method for second order elliptic problems. *J. Numer. Math.*, 10(4):249–274, 2002.
- [16] B. Cockburn, G. Kanschat, D. Schötzau, and C. Schwab. Local discontinuous Galerkin methods for the Stokes system. *SIAM J. Numer. Anal.*, 40(1):319–343, 2002.
- [17] S. Richling, E. Meinköhn, N. Kryzhevoi, and G. Kanschat. Radiative transfer with finite elements I. basic method and tests. *A&A*, 380:776–788, 2001.
- [18] B. Cockburn, G. Kanschat, I. Perugia, and D. Schötzau. Superconvergence of the local discontinuous Galerkin method for elliptic problems on cartesian grids. *SIAM J. Numer. Anal.*, 39(1):264–285, 2001.
- [19] G. Kanschat and F.-T. Suttmeier. A posteriori error estimates for nonconforming finite element schemes. *Calcolo*, 36(3):129–141, 1999.

- [20] G. Kanschat. A robust finite element discretization for radiative transfer problems with scattering. *East-West J. Numer. Math.*, 6(4):265–272, 1998.
- [21] C. Führer and G. Kanschat. A posteriori error control in radiative transfer. *Computing*, 58(4):317–334, 1997.

PAPERS SUBMITTED TO REFEREED JOURNALS

- [1] G. Kanschat and B. Rivière. A strongly conservative finite element method for the coupling of stokes and darcy flow. submitted.
- [2] H. K. Hesse and G. Kanschat. Mesh adaptive multiple shooting for partial differential equations. Part I: Linear quadratic optimal control problems. *J. Numer. Math.*, 2009. accepted for publication.
- [3] J.-L. Guermond and G. Kanschat. Asymptotic analysis of upwind dg approximation of the radiative transport equation in the diffusive limit. *SIAM J. Numer. Anal.*, 2009. submitted.

JOURNAL PAPERS IN PREPARATION

- [1] B. Janssen and G. Kanschat. Adaptive multilevel methods with local smoothing.
- [2] S. Zedler, R. Korty, I. Hoteit, and G. Kanschat. The sensitivity of the simulated ocean response to drag coefficient parameterization. 2009. in preparation.
- [3] J.-L. Guermond, G. Kanschat, and J. Ragusa. A discontinuous galerkin method for radiative transfer problems in the diffusive limit. 2009. in preparation.

PAPERS IN REFEREED CONFERENCE PROCEEDINGS

- [1] J. Gopalakrishnan and G. Kanschat. Multi-level preconditioners for the interior penalty method. In F. Brezzi, A. Buffa, S. Corsaro, and A. Murli, editors, *Numerical Mathematics and Advanced Applications: ENUMATH 2001*, pages 795–804, Milano, 2003. Springer Italia.
- [2] B. Cockburn, G. Kanschat, and D. Schötzau. LDG methods for Stokes flow problems. In F. Brezzi, A. Buffa, S. Corsaro, and A. Murli, editors, *Numerical Mathematics and Advanced Applications: ENUMATH 2001*, pages 755–764, Milano, 2003. Springer Italia.
- [3] R. Wehrse, E. Meinköhn, and G. Kanschat. A review of Heidelberg radiative transfer equation solutions. In P. Stee, editor, *Radiative Transfer and Hydrodynamics in Astrophysics*, pages 13–30. EDP Sciences, 2002.
- [4] G. Kanschat and F.-T. Suttmeier. A posteriori error estimates in the case of insufficient regularity of the discrete space. In B. Cockburn, G. E. Karniadakis, and C.-W. Shu, editors, *Discontinuous Galerkin Methods*, volume 11, pages 349–354. Springer, 2000.
- [5] G. Kanschat. Solution of multi-dimensional radiative transfer problems on parallel computers. In P. Bjørstad and M. Luskin, editors, *Parallel Solution of Partial Differential Equations*, volume 120 of *IMA Volumes in Mathematics and its Applications*, pages 85–96, New York, 2000. Springer.
- [6] R. Wehrse and G. Kanschat. Radiative fluxes and forces in non-spherical winds. In B. Wolf, O. Stahl, and A. W. Fullerton, editors, *Variable and Non-spherical Stellar Winds in Luminous Hot Stars*, pages 144–150. Springer, 1999.

PAPERS IN CONFERENCE PROCEEDINGS (NOT REFEREED)

- [1] G. Kanschat. Preconditioning discontinuous Galerkin saddle point systems. In K. J. Bathe, editor, *Computational Fluid and Solid Mechanics 2003*, pages 2016–2018. Elsevier, 2003.
- [2] J. Gopalakrishnan and G. Kanschat. Application of unified DG analysis to preconditioning DG methods. In K. J. Bathe, editor, *Computational Fluid and Solid Mechanics 2003*, pages 1943–1945. Elsevier, 2003.

- [3] B. Cockburn, G. Kanschat, and D. Schötzau. The local discontinuous Galerkin method in incompressible fluid flow. In H. A. Mang, F. G. Rammerstorfer, and J. Eberhardsteiner, editors, *Proceedings of the Fifth World Congress on Computational Mechanics (WCCM V)*. Vienna University of Technology, 2002.
- [4] G. Kanschat. Parallel computation of multi-dimensional neutron and photon transport in inhomogeneous media. In H.-J. Bungartz, F. Durst, and C. Zenger, editors, *High Performance Scientific and Engineering Computing*, volume 8, pages 431–440. Springer, 1999.
- [5] G. Kanschat. New algorithms for radiative transfer in accretion disks and surroundings. In D. T. Wickramasinghe, G. V. Bicknell, and L. Ferrario, editors, *Accretion Phenomena and Related Outflows; IAU Colloquium 163*, pages 736–737, San Francisco, California, 1997. Astronomical Society of the Pacific.
- [6] G. Kanschat. Efficient and reliable solution of multi-dimensional radiative transfer problems. In F. Karsch, B. Monien, and H. Satz, editors, *Multiscale Phenomena and Their Simulation*, pages 245–249, Singapore, 1997. World Scientific.
- [7] G. Kanschat. Parallel adaptive algorithms for radiative transfer problems. In P. Fritzon and L. Finmo, editors, *Parallel Programming and Applications*, volume 45 of *Transputer and OCCAM Engineering Series*, pages 238–243, Amsterdam, 1995. IOS Press.

PAPERS IN COLLECTIONS

- [1] G. Kanschat, E. Meinköhn, R. Rannacher, and R. Wehrse. The radiation field and its transfer equation. In G. Kanschat, E. Meinköhn, R. Rannacher, and R. Wehrse, editors, *Numerical Methods for Multi-Dimensional Radiative Transfer*, pages 1–18. Springer, 2008.
- [2] G. Kanschat. Solution of radiative transfer problems with finite elements. In G. Kanschat, E. Meinköhn, R. Rannacher, and R. Wehrse, editors, *Numerical Methods for Multi-Dimensional Radiative Transfer*, pages 49–98. Springer, 2008.
- [3] E. Meinköhn, G. Kanschat, R. Rannacher, and R. Wehrse. Numerical methods for multidimensional radiative transfer. In J. Jäger, R. Rannacher, and J. Warnatz, editors, *Reactive Flows, Diffusion and Transport*, pages 485–526. Springer, Berlin, 2006.

BOOKS

- [1] G. Kanschat, E. Meinköhn, R. Rannacher, and R. Wehrse, editors. *Numerical Methods for Multi-Dimensional Radiative Transfer*. Springer, 2008.
- [2] G. Kanschat. *Discontinuous Galerkin Methods for Viscous Flow*. Deutscher Universitätsverlag, Wiesbaden, 2007.
- [3] H. G. Bock, F. Brezzi, R. Glowinsky, G. Kanschat, Y. A. Kuznetsov, J. Périaux, and R. Rannacher, editors. *ENUMATH 97, Proceedings of the 2nd European Conference on Numerical Mathematics and Advanced Applications*, Singapore, 1998. World Scientific.

SOFTWARE MANUALS

- [1] W. Bangerth, R. Hartmann, and G. Kanschat. `deal.II Differential Equations Analysis Library`, *Technical Reference*, 6.2 edition, 2008. first edition 1999.
- [2] W. Bangerth and G. Kanschat. Concepts for object-oriented finite element software – the `deal.II` library. Preprint 1999-43, SFB 359, Heidelberg, 1999.

MISCELLANEOUS

- [1] G. Kanschat and E. Meinköhn. Multi-model preconditioning for radiative transfer problems. Preprint 2004-33, SFB 359, Heidelberg, 2004.
- [2] G. Kanschat. *Discontinuous Galerkin Finite Element Methods for Advection-Diffusion Problems*. Habilitationsschrift, Universität Heidelberg, 2003.
- [3] G. Kanschat. *Parallel and Adaptive Galerkin Methods for Radiative Transfer Problems*. Dissertation, Universität Heidelberg, 1996. Preprint SFB 359, 1996-29.

13 RESEARCH

The aim of my research is the efficient solution of challenging problems in applied sciences involving partial differential equations (PDE). In order to achieve this goal, it is necessary to understand every component from discretization of the PDE to the actual implementation. Consequently, my research activities are divided into four parts:

13.1 NON-STANDARD FINITE ELEMENT DISCRETIZATIONS

I have been developing strongly divergence free discretizations for incompressible flow problems, mostly in collaboration with B. Cockburn (U. of Minnesota) and D. Schötzau (U. of British Columbia). These schemes use special, divergence-conforming elements and are based on earlier work on discontinuous Galerkin methods (DGFEM), in particular the LDG method. I am author of several publications on the a priori and a posteriori error analysis of these schemes. Currently, this involves point-wise conservative *continuous* methods for incompressible flow and discretizations of neutron transport problems honoring the energy balance.

I have been working intensely on DGFEM, most recently with R. Hoppe (U. of Houston) and T. Warburton (Rice U.) on convergent adaptive methods; currently, we are collaborating on a recently awarded NSF-grant to develop tuning-free DGFEM methods for Maxwell equations.

In conjunction with a project with J.-L. Guermond and R. Lazarov (Texas A&M), these results are currently being extended to singularly perturbed problems. Together with M. L. Adams J.-L. Guermond, R. Lazarov and J. Ragusa (Texas A&M), I am developing and improving DGFEM for neutron and radiation transport problems. These methods are applied for instance in a project on uranium detection funded by the Department of Homeland Security.

13.2 LINEAR SOLVERS

These discretizations are only as valuable as it is possible to solve the linear systems arising from them in reasonable time. In particular, efficient preconditioning techniques are required within quasi-Newton iterations in order to solve the nonlinear problems mentioned above efficiently.

Therefore, I have been developing efficient solvers for the discrete problems arising in the discretizations mentioned above. This includes the first multilevel preconditioners for a major group of DGFEM discretizations (with J. Gopalakrishnan, U. of Florida) and their efficient application to the saddle point problems arising in incompressible flow. These preconditioners perform excellently for higher order methods, on locally refined meshes and in advection-dominated regimes. In the analysis of these preconditioners I am currently focusing on the latter aspects. A recent project which funded by NSF-DMS involves multilevel methods for DG discretizations of Maxwell problems (with R. Hoppe, U. of Houston and T. Warburton, Rice U.) with a focus on local smoothing during adaptive mesh refinement cycles.

13.3 SOFTWARE DEVELOPMENT AND PARALLELIZATION

The application and evaluation of new numerical methods requires efficient and flexible software tools. These should combine ease of operation with full control over every aspect of the solution process and runtime efficiency. Since no commercial software reaches these goals, I founded the DEAL project in 1992 with F.-T. Suttmeier (University of Siegen, Germany), developing object oriented concepts and first implementations, which are still used as base of software packages like Gascoigne and the Heidelberg Radiative Transfer Code. In 1998, these preparations led to the object oriented software library `deal.II` (together with W. Bangerth, Texas A&M University and R. Hartmann, DLR (German Aerospace Foundation)). It is publicly available (www.dealii.org; several hundred downloads worldwide for the current version within 2 months). It is probably the only freely available software tool combining adaptive meshes in two and three dimensions with multilevel support and vector elements. It was awarded the *J. H. Wilkinson Prize for Numerical Software* in 2007.

Currently, support for shared memory parallelization is part of this library. Support for distributed memory architectures is provided using automatic partitioning with METIS and the parallel linear algebra of Petsc. I am currently developing an approach which allows dynamic load balancing without storing a whole discretization mesh on all processors relying on local refinement of the subregion handled by the processor in charge. This approach will use

standardized interface objects within the `deal.II` library, such that it will automatically benefit all applications based on this library.

13.4 SCIENTIFIC AND TECHNICAL APPLICATION

Since my PhD thesis on parallel and adaptive finite element methods for radiative transfer problems, I have been working in close cooperation with colleagues in theoretical physics. The aim was the development of a fast solver for monochromatic radiative transfer problems, tailored to the special needs of the applied scientist involved. The project is still being continued and the software is continuously adapted to additional needs by astrophysics applications. Currently, it is used to compute emission line profiles of moving protostellar clouds.

Neutron transport and radiative transfer problems are particularly demanding with respect to computer resources, since the computational domain is five-dimensional for the simplest model. Therefore, medium scale parallelization (with up to 160 processors), adaptive mesh generation based on optimal a posteriori error estimates and the application of efficient solution methods had to be implemented to obtain reasonably accurate simulation results at all. Recently, the experience gained in DGFEM has been applied to this project. Here, its features are used to achieve model adaptivity in the method, depending on the highly varying coefficients. This whole radiative transfer project was funded by DFG with me starting as a PhD student and becoming PI later. After transferring to Texas A&M University, I have been continuing work on radiative transfer in collaboration with colleagues in the Department of Nuclear Engineering.

Currently, I am building collaborations with colleagues in atmospheric sciences, oceanography and geophysics, where I apply my experience on and methods for flow problems to the highly stratified flows occurring there. In a first step, we studied a parameter identification problem at the interface between hurricanes and ocean surface (with my post doc S. Zedler in IAMCS, I. Hoteit and R. Korty). Furthermore, we are developing a high accuracy scheme with low numerical diffusion to study heat transfer mechanisms in the paleo-ocean.

In my future work, I will continue the tradition of working closely with applied scientists and engineers in order to improve numerical schemes with respect to their applicability and to promote mathematically sound solution techniques for applications in science and industry.

14 TEACHING STATEMENT

One of my main goals in teaching is making students understand not only the techniques and facts of the topic at hand, but also its relations to topics already known. It is important to find a balance between concrete study of the current topic and mathematical abstraction, depending on the level of the course and the type of audience.

I tend to devote a considerable part of the course to pose the material in form of questions to be answered by the students. This way, students gain confidence in their acquired abilities and are encouraged to explore. Furthermore, they learn discussing about mathematical topics.

In the beginning of a course, I ask my students to form study groups of three to four members for preparation of their homework. This process is formalized by requiring every student to register with one group. My experience over the last years is that at least some of these groups continue discussing their work during the semester, which becomes visible through increased classroom participation and improving grades. Usually, stronger as well as weaker students profit from this system, the latter by explanations gotten from their peers, the former by a much deeper engagement in the material. Naturally, I point out the difference between joint preparation of homework and simple copying.

I have given courses on various topics in numerical analysis, where I make sure to link the presentation of the theoretical results to their practical implications. These courses are complemented by practical sessions, allowing students to see how the concepts taught actually work.

Additionally, I taught several mathematics classes populated predominantly by engineering students; here, the balance between mathematical theory on the one hand and application on the other is very important. While conveying some of the mathematical background, the use and judgement of the methods presented should be considered more important.

Between 2001 and 2004, I have developed and taught a course on C++ programming for numerical applications, which did not exist at the University of Heidelberg before. This course consists of practical sessions with tutorials interspersed. Its focus is on gaining programming experience and developing a good style and it is organised such that programming techniques are acquired as they are needed to complete a given project (e.g. a solver for a discretised PDE) at the end of the semester.

15 SERVICE STATEMENT

I strongly believe that faculty participation in administration is very important for the efficient and effective operation of a university. While I do not expect to be able to compete with professional administrators when it comes to actually running a big institution, I see the value of my input in my experience with the actual teaching and research operation. Therefore, I consider it as my obligation as member of the faculty to assist where my advice is asked for. For instance, I served on two panels for the Dean of Faculties.

In order to have qualified opinions, I consider it necessary to be informed about proceedings at the university and acquire knowledge about the structure and decision making processes. I joined the Faculty Senate in 2007 in order to obtain this insight and be a contributing part of the campus community. I am also an active member of two faculty networks and officer of one of them.

For the future, I am looking forward to continue being an active member of the faculty of my department, college and Texas A&M University and accomplish my share in administrative duties while balancing these with my teaching and research time.