

GUIDO KANSCHAT

Assistant Professor

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Department of Mathematics

Texas A&M University

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1 EDUCATION

2004 *Habilitation and venia legendi*, Mathematics, University of Heidelberg, Germany

1996 *Doctor rer. nat.* (PhD in Science), University of Heidelberg, Germany

1992 *Diplom*, Mathematics, University of Bonn, Germany

2 APPOINTMENTS

2006- Assistant Professor, Texas A&M University

2005-2006 Research Associate (*Wiss. Ang.*), Department of Applied Mathematics, University of Heidelberg, Germany

2000-2005 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

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

2007 NSF-DNDO grant “ARI-LA: A Framework for Developing Novel Detection Systems Focused on Interdicting Shielded HEU”, Warren Miller, PI

2007 NSF-DMS grant “Discontinuous Galerkin Methods for PDEs with Heterogeneous Coefficients”, Jean-Luc Guermond, PI

2000 DFG *Schwerpunktprogramm ANumE*, Rolf Rannacher, PI, 4 years

1999 DFG *Habilitationsstipendium* (postdoctoral scholarship), 5 months

1992 DFG Graduate Scholarship, 3 years

4 CONFERENCES AND MINISYMPOSIA (ORGANIZATION)

- International Conference on Modeling, Simulation and Optimization of Complex Processes in honor of the 60th birthdays of H. G. Bock and R. Rannacher, Heidelberg, 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 901” 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

5 SCIENTIFIC COMPUTING

- Profound experience in object-oriented programming especially in the development of software libraries for scientific computing (www.dealii.org).
- Experience with parallelization on various computer systems from Transputer grids to workstation clusters up to 256 nodes.
- Programming experience in C++, C, Pascal, Java, JavaScript, FORTRAN
- Seven years experience as network administrator.

6 COLLABORATORS

- | | |
|------------------------------------------------|------------------------------------------------------------------|
| • W. Bangerth, Texas A&M University | Germany |
| • B. Cockburn, University of Minnesota | • S. Richling, Institut d’ Astrophysique de Paris, France |
| • J. Gopalakrishnan, University of Florida | • D. Schötzau, University of British Columbia, Vancouver, Canada |
| • R. Hartmann, DLR, Braunschweig, Germany | • Ch. Schwab, ETH Zürich, Switzerland |
| • H. K. Hesse, Universität Heidelberg, Germany | • F.-T. Suttmeier, Universität Siegen, Germany |
| • R. H. W. Hoppe, University of Houston | • T. Warburton, Rice University, Houston |
| • E. Meinköhn, Universität Heidelberg, Germany | • R. Wehrse, Universität Heidelberg, Germany |
| • I. Perugia, Università di Pavia, Italy | |
| • R. Rannacher, Universität Heidelberg, | |

7 STUDENT THESES

7.1 THESIS ADVISOR

- 2 Diploma (Ch. Laux, B. Janssen)

7.2 THESIS CO-ADVISOR

- 2 PhD (H. Hesse, R. Zamni)
- 4 Diploma (W. Bangerth, R. Hartmann, B. Lienerth, A. Wild)
- 2 *Staatsexamen* (A. Kürbs, I. Krause)

7.3 EXTERNAL REFEREE

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

8 INVITED PRESENTATIONS

2007

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

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

9 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 can be divided into four parts:

9.1 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 coinvestigator of a DFG (German Research Foundation) grant on adaptive DGFEM for Euler equations and currently I am part of two grants awarded by NSF (National Science Foundation, USA), namely on DGFEM for problems with heterogeneous degenerating coefficients (with J.-L. Guermond, R. Lazarov, Texas A&M) and on detection of nuclear material (a consortium at Texas A&M involving about 20 investigators in five departments).

9.2 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. With a PhD student, I am also studying the interplay of Newton iteration and adaptive mesh refinement. A recent project which is being proposed to the NSF involves multilevel methods for DG discretizations of Maxwell problems (with R. Hoppe, U. of Houston and T. Warburton, Rice U.)

9.3 SOFTWARE DEVELOPMENT AND PARALLELIZATION

The application and evaluation of new numerical methods requires efficient and flexible software tools. These should combine ease of use 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 and Philips BV, Eindhoven obtained a commercial license for this software for biomedical devices.

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.

9.4 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, where all applications were written by myself.

Together with a PhD student (H. Hesse), I am working on the application of adaptive DGFEM schemes to multiple shooting methods for transient problems in PDE with a focus on optimal control within a DFG grant of PhD scholarships. Furthermore, I acquired payment for a diploma thesis of one of my students by R. Bosch GmbH, Reutlingen for the simulation of transport and condensation of humidity in electronic automotive devices.

In my future work, I am planning to continue the tradition of working closely with applied scientists and engineers in order to improve numerical schemes with respect to their applicability and to convey the use of mathematically sound solution techniques for partial differential equations to applications in science and industry.

10 PUBLICATIONS

PAPERS IN REFEREED JOURNALS

- [1] 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.
- [2] G. Kanschat. Robust smoothers for high order discontinuous galerkin discretizations of advection-diffusion problems. *J. Comput. Appl. Math.*, 2007. published online.
- [3] 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.
- [4] W. Bangerth, R. Hartmann, and G. Kanschat. deal.II — a general purpose object oriented finite element library. *ACM Trans. Math. Softw.*, 33(4), 2007.
- [5] G. Kanschat. Block preconditioners for LDG discretizations of linear incompressible flow problems. *J. Sci. Comput.*, 22(1):381–394, 2005.
- [6] B. Cockburn, G. Kanschat, and D. Schötzau. A locally conservative LDG method for the incompressible Navier-Stokes equations. *Math. Comput.*, 74:1067–1095, 2005.
- [7] 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.
- [8] G. Kanschat. Multi-level methods for discontinuous Galerkin FEM on locally refined meshes. *Comput. & Struct.*, 82(28):2437–2445, 2004.
- [9] G. Kanschat. Preconditioning methods for local discontinuous Galerkin discretizations. *SIAM J. Sci. Comput.*, 25(3):815–831, 2003.
- [10] J. Gopalakrishnan and G. Kanschat. A multilevel discontinuous Galerkin method. *Numer. Math.*, 95(3):527–550, 2003.
- [11] B. Cockburn, G. Kanschat, and D. Schötzau. The local discontinuous Galerkin method for the Oseen equations. *Math. Comput.*, 73(246):569–593, 2003.
- [12] 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.
- [13] 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.
- [14] 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.
- [15] 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.

- [16] G. Kanschat and F.-T. Suttmeier. A posteriori error estimates for nonconforming finite element schemes. *Calcolo*, 36(3):129–141, 1999.
- [17] G. Kanschat. A robust finite element discretization for radiative transfer problems with scattering. *East-West J. Numer. Math.*, 6(4):265–272, 1998.
- [18] 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 D. Schötzau. Energy norm a-posteriori error estimation for divergence-free discontinuous Galerkin approximations of the navier-stokes equations. *Int. J. Numer. Methods Fluids*, 2007. accepted for publication.
- [2] R. H. W. Hoppe, G. Kanschat, and T. Warburton. Convergence analysis of an adaptive interior penalty discontinuous Galerkin method. *SIAM J. Numer. Anal.*, 2007. submitted.
- [3] H. K. Hesse and G. Kanschat. Mesh adaptive multiple shooting for partial differential equations. Part I: Linear quadratic optimal control problems. *SIAM J. Sci. Comput.*, 2007. submitted.

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. Fritzson and L. Finmo, editors, *Parallel Programming and Applications*, volume 45 of *Transputer and OC-CAM 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*. Springer, 2008. to appear.
- [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*. Springer, 2008. to appear.
- [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*. Springer, Berlin, 2006.

BOOKS

- [1] G. Kanschat, E. Meinköhn, R. Rannacher, and R. Wehrse, editors. *Numerical Methods for Multi-Dimensional Radiative Transfer*. Springer, 2008. to appear.

- [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*. www.dealii.org, 6.0 edition, 2007. 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.

11 TEACHING

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. Ideally, my students work on those in small groups and discuss the results. This way, students gain confidence in their acquired abilities and are encouraged to explore. Furthermore, they learn discussing about mathematical topics.

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. My mathematical background is sufficiently broad to teach undergraduate courses in mathematics in general and graduate courses in applied mathematics with a focus on analysis and numerical analysis.

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.

Furthermore, I have successfully supervised students preparing their graduate (*Diplom* and *Staatsexamen*) theses (4 finished plus one current) and PhD theses (2 current) on various topics in numerical analysis of ordinary and partial differential equations.

12 TEACHING RECORD

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)