

Associate Prof. Dr. Alfio Borzi

Institute for Mathematics and Scientific Computing

Karl-Franzens-University Graz, Heinrichstrasse 36, A-8010 Graz, Austria

Personal data

Date and place of birth 01.03.1965 in Catania, Italy

Citizenship: Italian

Education

1983 - 1988 Master in Physics, University of Catania.

(Title: Sulla Applicazione Rigorosa in Fisica del Calcolo Variazionale - On rigorous application of variational calculus in physics)

1988 - 1990 Master Philosophy (M.Ph.) in Mathematics, SISSA/ISAS-International School for Advanced Studies, Trieste.

(Title: Fourier Spectral Methods for Soliton Equations)

1992 - 1993 Doctor Philosophy (Ph.D.) in Mathematics, SISSA/ISAS-International School for Advanced Studies, Trieste.

(Title: New Aspects of Multilevel Methods and Some Applications)

1998 - 2003 Habilitation at Karl-Franzens-University Graz, 2003.

(Title: Multigrid Methods for Optimality Systems)

Additional education

1997 Academy of Management, WIFI Graz.

1996 Administration of UNIX operative systems, Hewlett-Packard, Boeblingen (D) and Vienna (A).

1996 Development and Administration of Databases, Informix, Ismaning (D).

1995 Networks Technologies, Techno-Z, Salzburg (A).

1991 Management of Personnel and Logistic, AMI, Scuola di Guerra Aerea, Firenze (I).

1991 Meteorology and Numerical Wether Prediction, CNMCA, Roma (I).

Professional development

Since 2003 Associate Professor at Institute for Mathematics and Scientific Computing Karl-Franzens-University Graz.

Main topics: Teaching and 1) Numerical solution of optimization problems. 2) Development and analysis of multigrid methods. 3) Analysis of discretization schemes for partial differential equations. 4) Modeling and numerical solution of gas dynamics problems. 5) Mathematics of vision.

1998 - 2003 Assistant Professor at Institute for Mathematics and Scientific Computing Karl-Franzens-University Graz.

1998 - 2001 Consultant, Office for technical Simulation.

1997 - 1998 Research Engineer, AVL List GmbH, Graz.

Main topics: 1) Implementation of "High-Order Discretization" schemes for finite volumes for CFD. 2) Development of iterative solvers. 3) Implementation of cell-face data structures for unstructured grid computation.

1996 - 1997 IT System-administrator, SPAR AG, Salzburg.

Main topics: 1) UNIX Administration. 2) Informix Databases administration. 3) Setting of Intranet, E-mail, Firewall, etc.

1993 - 1995 Research Officer, Oxford University Computing Laboratory, Oxford.

Main topics: Teaching and 1) Development and analysis of multigrid methods for Cell Vertex Finite Volume Methods. 3) Analysis of Cell Vertex Finite Volume Discretization. 4) Collaboration in european Project for the development of a Database of CFD algorithms.

1991 - 1992 Italian Air Force Officer, Centro Nazionale di Meteorologia e Climatologia, CNMCA, Roma.

Main topics: 1) Development and validation of Kalman Filters. 2) Analysis von Weather data.

Teaching

- Analysis I and II
- Linear Algebra I and II
- Optimization I and II

- Complex Analysis
- Functional analysis
- Ordinary Differential Equations
- Programming in C++
- Numerical Analysis I
- Theory of Partial Differential Equations
- Multilevel methods in optimization with PDE models
- Numerical Solution of Partial Differential Equations

Editor Duty

Associate Editor of SIAM Journal on Scientific Computing.
 Numerical Mathematics: Theory, Methods and Applications (NM-TMA)

Grants & Projects

- MGINV-MOBIS, SFB Mathematical Optimization with Applications to Biomedical Sciences, Fast Multigrid Methods for Inverse Problems. Supported by the Austrian Science Fund FWF
- FWF Grant: Quantum optimal control of semiconductor nanostructures, FWF project P18136-N13.
- Fast Solvers for Computational Problems Arising in Pharmacy, Life Sciences, Mathematics, Physics, and the Environment (Douglas, Langer, et al.), Supported by NSF.
- A computational framework for real-time identification of hazardous events (Biros, Willcox, et al.) Supported by NSF
- Image-Driven Inverse Cardiac Modeling Project (Ghattas et al.), Supported by NSF.
- Real time optimization for data assimilation and control of large scale dynamic simulations (Ghattas, Biros, et al.), Supported by NSF

Industrial Projects (with AVL List GmbH, Graz)

- SWIFT AMG.
- PARALLEL SWIFT AMG: Investigation and Development.
- Boundary Conditions Calculation in BOOST.
- The Simulation of the Gas Dynamics with Perforated Pipes in Plenum or in Pipes with BOOST.
- Comparison of Multigrid and SOR for the Solution of the Reynolds Equation.

Organized Workshops/Conferences

- Workshop Advances in Numerical Algorithms, Graz, September 10-13, 2003. (mit K. Kunisch)
- GAMM 2006 Minisymposium "Multigrid Methods for Optimal Control of PDEs", Berlin, March 27-31, 2006. (with B. Vexler)
- Member of Local Organizing Committee for the Conference "Domain Decomposition Methods DD17", St. Wolfgang/Strobl, July 3-7, 2006.
- SIAM Annual Meeting 2006 Minisymposium "Multilevel Methods for Optimization and Inverse Problems", USA, Boston, July 10-14, 2006. (with G. Biros)
- Member of Local Organizing and Scientific Committee for the "ENUMATH 2007" Conference, Graz, September 10-14, 2007.

Some visiting activities

Tinsley Oden Fellow, Institute for Computational Engineering and Sciences, University of Texas at Austin, USA (2007). Centre of Mathematics for Applications, University of Oslo (2006). Department of Mathematics, University of the Philippines, Diliman, Philippines (2005). Computer Science Department, Technion, Haifa, Israel (2004). Department of Mathematics, KAIST, Taejon, South Korea (2001).

Languages: German (Good), English (Good), Italian (Good)

Publications

- [1] A. Borzì and U. Hohenester, Multigrid optimization schemes for solving Bose–Einstein condensates control problems, to appear in SIAM J. Sci. Comp.

- [2] P. Ditz and A. Borzì, A cascadic monotonic time-discretized algorithm for finite-level quantum control computation, to appear in *Computer Physics Communications*
- [3] A. Borzì, J. Salomon, and S. Volkwein, Formulation and numerical solution of finite-level quantum optimal control problems, *Journal of Computational and Applied Mathematics*, 2007.
- [4] U. Hohenester, P.K. Rekdal, A. Borzì, J. Schmiedmayer, Optimal quantum control of Bose-Einstein condensates in magnetic microtraps, *Phys. Rev. A* 75, 023602 (2007)
- [5] A. Borzì, Smoothers for control- and state-constrained optimal control problems, to appear in *Computing and Visualization in Science*.
- [6] A. Borzì, High-order discretization and multigrid solution of elliptic nonlinear constrained optimal control problems, *Journal of Computational and Applied Mathematics* (doi:10.1016/j.cam.2005.12.023).
- [7] A. Borzì and R. Griesse, Distributed optimal control of lambda-omega systems, *Journal of Numerical Mathematics*, 14 (2006), 17-40.
- [8] A. Borzì and G. Borzì, Algebraic multigrid methods for solving generalized eigenvalue problems, *International Journal for Numerical Methods in Engineering*, 65(8) (2006), 1186-1196.
- [9] A. Borzì and E. Decker, Analysis of a leap-frog pseudospectral scheme for the Schroedinger equation, *Journal of Computational and Applied Mathematics*, 193(1) (2006), 65-88.
- [10] A. Borzì and K. Kunisch, A globalization strategy for the multigrid solution of elliptic optimal control problems, *Optimization Methods and Software*, 21(3) (2006), 445-459.
- [11] A. Borzì, H. Grossauer, and O. Scherzer, Analysis of Iterative Methods for Solving a Ginzburg-Landau Equation, *Int. Journal of Computer Vision*, 64 (2005), 203-219.
- [12] A. Borzì and R. Griesse, Experiences with a space-time multigrid method for the optimal control of a chemical turbulence model, *Int. J. Numer. Meth. Fluids.*, 47 (2005), 879-885.
- [13] A. Borzì, Solution of lambda-omega systems: Theta-schemes and multigrid methods, *Numerische Mathematik*, 98(4) (2004), 581-606.

- [14] A. Borzì and K. Kunisch, A multigrid scheme for elliptic constrained optimal control problems, *Computational Optimization and Applications*, 31 (2005), 309-333.
- [15] A. Borzì and G. Borzì, An efficient algebraic multigrid method for solving optimality systems, *Computing and Visualization in Science*, 7(3/4) (2004), 183-188.
- [16] A. Borzì and G. Borzì, An algebraic multigrid method for a class of elliptic differential systems, *SIAM J. Sci. Comp.*, 25(1) (2003), 302-323.
- [17] A. Borzì, Multigrid methods for parabolic distributed optimal control problems, *J. Comp. Appl. Math.*, 157 (2003), 365-382.
- [18] P. Bartsch and A. Borzì, On the Modeling and Simulation of Boundary Flow Through Partially Open Pipe Ends, *ZAMP*, 55 (2004), 946-961.
- [19] A. Borzì, G. Stadler, and U. Hohenester, Optimal quantum control in nanostructures: Theory and application to a generic three-level system, *Phys. Rev. A* 66, 053811 (2002).
- [20] A. Borzì and G. Propst, Numerical Investigation of the Liebau Phenomenon, *ZAMP*, 54 (2003), 1050 - 1072.
- [21] A. Borzì, K. Kunisch, and Do Y. Kwak, Accuracy and Convergence Properties of the Finite Difference Multigrid Solution of an Optimal Control Optimality System, *SIAM J. Control Opt.*, 41(5) (2003), 1477-1497.
- [22] A. Borzì, K. Ito, and K. Kunisch, Optimal Control Formulation for Determining Optical Flow, *SIAM J. Sci. Comput.*, 24(3) (2002), 818-847.
- [23] A. Borzì, K. Ito, and K. Kunisch, An Optimal Control Approach to Optical Flow Computation, *Int. J. Numer. Meth. Fluids.*, 40 (2002), 231-240.
- [24] A. Borzì and K. Kunisch, The Numerical Solution of the Steady State Solid Fuel Ignition Model and Its Optimal Control, *SIAM J. Sci. Comp.*, 22(1) (2000), 263-284.
- [25] A. Borzi, K.W. Morton, E. Süli and M. Vanmaele, Multilevel Solution of Cell Vertex Cauchy-Riemann Equations, *SIAM J. Sci. Comp.*, 18(2) (1997), 441-459.
- [26] M. Vanmaele, K.W. Morton, E. Süli and A. Borzi, Analysis of the Cell Vertex Finite Volume Method for the Cauchy-Riemann Equations, *SIAM J. Num. Anal.*, 34(5) (1997), 2043-2062.
- [27] A. Borzi and A. Koubek, A multi-grid method for the resolution of thermodynamic Bethe ansatz equations, *Comp. Phys. Commun.*, 75 (1993), 118-126.

- [28] A. Borzi and G. Fonte, On Variational principles for Nonlinear Partial Differential Equations in Complex Spaces, *Nuovo Cimento*, B107, 189-201,(1992).

Books & Proceedings

- [29] A. Borzi, On the convergence of the MG/OPT method, *PAMM, Proceedings GAMM Annual Meeting - Luxembourg 2005*, 5(1) (2005), 735-736.
- [30] A. Borzi, Space-time multigrid methods for solving unsteady optimal control problems, to appear in the *Proceedings of the Second Sandia Workshop on PDE-Constrained Optimization: Toward Real-time and Online PDE-constrained Optimization*, May 19-21, 2004, Bishop's Lodge, Santa Fe, New Mexico. Workshop organizing committee: Larry Biegler, Omar Ghattas, Matthias Heinkenschloss, David Keyes, Bart van Bloemen Waanders.
- [31] A. Borzi, Fast multigrid methods for parabolic optimal control problems, *Proceedings of 18-th GAMM Seminar Leipzig 2002*.
- [32] G. Propst and A. Borzi, Numerical Investigation of periodically excited valveless pumping, in *Simplicity behind Complexity*, W. Klonowski (Ed.), *Proceedings of Euroattractor 2002*, Warsaw, Pabst science publishers, pp. 192-200.
- [33] A. Borzi, K. Ito and K. Kunisch An Optimal Control Approach to Optical Flow Computation, In M J Baines, editor, *Numerical Methods for Fluid Dynamics VII*, ICFD, Oxford University Computing Laboratory, 2001.
- [34] P. Bartsch, B. Bachner, A. Borzi, and H.A. Schuemie, Simulation of a Concentric-Tube Resonator, in *International Symposium on Experimental and Computational Aerothermodynamics of Internal Flows 5th ISAIF*, 4 - 7 September 2001 Gdansk.
- [35] A. Borzi and K. Kunisch, A Multigrid Method for the Optimal Control of Time-Dependent Reaction Diffusion Processes, in K.H. Hoffmann, R. Hoppe, and V. Schulz (Eds.), "Fast solution of discretized optimization problems", *International Series on Numerical Mathematics*, Vol. 138, Birkhuser, 2001.
- [36] P. Bartsch and A. Borzi, A New Reconstruction Technique for the Euler Equations of Gas Dynamics with Source Terms, in E. Toro (Ed.), "Godunov Methods: Theory and Applications", Kluwer Academic/Plenum Publishers, 2001.
- [37] A. Borzi and G. Borzi, Algebraic Multigrid and Conjugate Gradient Methods for the Solution of FEM Equations for 3D Static Problems, *9th IGTE Symposium on Numerical Field Calculation in Electrical Engineering*, Graz (Austria), 11-14 settembre, 2000.

- [38] A. Borzi, K. Kunisch, and M. Vanmaele, A Multi-Grid Approach to the Optimal Control of Solid Fuel Ignition Problems, in E. Dick, K. Riemslagh and J. Vierendeels (Eds.), Lecture Notes in Computer Science and Engineering, 14, European Multigrid Meeting 1999, Springer 2000.
- [39] A. Borzi, K.W. Morton, E. Süli and M. Vanmaele, A full multi-grid method for the solution of the cell vertex Cauchy-Riemann equations, in "Seventh Copper Mountain Conference on Multigrid Methods", ed. by N.D. Melson, T.A. Manteuffel, S.F. McCormick and C.C. Douglas, 73-86, NASA, Hampton, (1996).
- [40] A. Borzi, Burgers Equation and Multi-Grid Techniques, in "Contributions to Multigrid" ed. by P.W. Hemker and P. Wesseling, CWI, Amsterdam, (1994).
- [41] A. Borzi, On the Extension of the Twolevel Method for Operator Equations in Hilbert Space, in "Contributions to Multigrid" ed. by P.W. Hemker and P. Wesseling, CWI, Amsterdam, (1994).
- [42] A. Borzi and A. Koubek, On a multi-grid algorithm for the TBA equations, in "Multigrid Methods IV", ed. by P.W. Hemker and P. Wesseling, Birkhaeuser Verlag, Basel, (1994).

Skripten (<http://www.uni-graz.at/imawww/borzi/teaching.html>)

'Multilevel methods in optimization with partial differential equations'.

'A very short introduction to multigrid methods'.

'Numerische Mathematik für LAK'.

'Differentialgleichungen für LAK'.

'Programming in C++'.

Algorithmen

- [1] SANTAFE: A space-time multigrid method for open-loop (and receding-horizon) optimal control of time-dependent reaction-diffusion systems (2005). In MGNet: MGNet Home Page.
- [2] CONTROLLA: A full multigrid method for the solution of an optimality system arising from a singular optimal control problem. In MGNet: MGNet Home Page.
- [3] INTEGRA: A multigrid code for the solution of systems of nonlinear integral equations. In MGNet: MGNet Home Page.
- [4] TBA: A multigrid code for the solution of the thermodynamic Bethe Ansatz equations. In CPC Program Library: CPC Program Library Home Page.