

Curriculum Vitae

ANDREAS KLOECKNER

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Education

- 2010 Ph.D. in Applied Mathematics
Division of Applied Mathematics, Brown University, Providence, RI
High-Performance High-Order Simulation of Wave and Plasma Phenomena
- 2006 M.Sc. in Applied Mathematics
Division of Applied Mathematics, Brown University, Providence, RI
- 2005 Diplom degree in Applied Mathematics (Technomathematik)
Institut für Angewandte Mathematik, Universität Karlsruhe, Germany
On the Computation of Maximally Localized Wannier Functions

Experience

- 8/2013 – Assistant Professor
Computer Science, University of Illinois at Urbana-Champaign
- 1/2016 – Affiliate Faculty Member
Electrical and Computer Engineering, University of Illinois at Urbana-Champaign
- 9/2010 – 7/2013 Courant Instructor
Courant Institute of Mathematical Sciences, New York University, New York City
Designed and analyzed new numerical methods supporting the use of boundary integral equations in computational electromagnetics and other applications. (with Leslie Greengard)
- 2007 – 2010 Graduate Research Assistant
Division of Applied Mathematics, Brown University, Providence, RI
Designed efficient, scalable solvers for time-domain electromagnetics. Designed and analyzed new shock detection schemes for high-order discontinuous Galerkin methods. (with Jan Hesthaven and Tim Warburton)
- 6/2006 – 9/2006 J. Wallace Givens Research Associate
Mathematics and Computer Science Div., Argonne Nat'l Laboratory, Illinois
Designed high-order unstructured electromagnetic simulation methods for particle accelerators. (with Paul Fischer, Misun Min, and colleagues at ANL's Advanced Photon Source)

Awards and Achievements

2018	University of Illinois Engineering Council Outstanding Advising Award
2017	National Science Foundation CAREER Award (Computational Mathematics Program, grant number DMS-1654756)
2016	C.W. Gear Outstanding Junior Faculty Award (Dept. of Computer Science, University of Illinois at Urbana-Champaign)
2015	Recipient of Google ‘Gift for Open Source Friends’ for work on <code>pubb</code>
2015	‘List of teachers ranked as excellent by their students’, University of Illinois at Urbana-Champaign, Spring 2015.
2015	‘Best minisymposium’ on ‘Scalable Finite Element Assembly’ at SIAM Computational Science and Engineering (Salt Lake City, UT) (presented one of the constituent posters)
2013	Travel Award for SIAM Conference on Computational Science and Engineering (Boston, MA)
2012	NSF US Junior Oberwolfach Fellowship Travel grant to attend the Oberwolfach workshop “Theory and Applications of Discontinuous Galerkin Methods”
2012	Travel Award for SIAM Conference on Parallel Processing for Scientific Computing (Savannah, GA)
2010	David Gottlieb Memorial Award of the Division of Applied Mathematics at Brown University
2010	NSF US Junior Oberwolfach Fellowship Travel grant to attend the Oberwolfach workshop “Computational Electromagnetism and Acoustics”
2009	Brown University Dissertation Fellowship
2001	DaimlerChrysler Scholarship Program

Research

The unifying theme of my research interest is the efficient numerical simulation of wave phenomena. I have worked towards this goal by pursuing a broad range of topics:

Efficient Building Blocks for Integral Equation Methods. Together with Alexander Barnett and Leslie Greengard, I have recently publicized details of a novel, fast, and general scheme to compute Nyström discretizations of layer potential operators for the Helmholtz and Laplace PDEs at a high order of accuracy, termed ‘Quadrature by Expansion’ (QBX). This work holds tremendous promise as a tool for building PDE solvers capable of attacking current engineering problems at scale. My current work aimed at delivering on this promise includes methods for precise error control, automatic adaptivity, and integration with fast algorithms and computational tools.

Tools for Scientific Programming. The advent of massive on-chip parallelism is in the process of turning commonly accepted cost metrics in numerical analysis on their heads. This phenomenon includes, but is not limited to, GPU hardware. Increasingly, proof-of-concept implementations (e.g. in MATLAB) risk being unaware of the drivers of computational cost, and, consequently, are prone to producing methods that are not scalable on actual hardware. Making current computer architectures accessible to numerical analysts is a question of tools and abstractions. I am pursuing a long-term program to develop such a set of languages and tools fundamentally based on the notion of run-time code generation, presenting an alternative point of view to commonly accepted software construction practice.

Numerical Methods for Hyperbolic PDEs. Using time-explicit discontinuous Galerkin (“DG”) methods as a starting point, I am investigating problems arising in applications, such as those arising in computational electromagnetics, as well numerical subjects, such as detection and mitigation methods for Gibbs phenomena encountered in shock-laden flows. I have further developed a number of multi-rate time integration methods to be used in conjunction with DG.

Publications

See <http://goo.gl/sjZ2E> for a research impact summary compiled by Google Scholar.

Journal Articles

- 2018 Multi-Rate Time Integration on Overset Meshes.
C. Mikida, A. Klöckner, D. Bodony
Submitted to Journal of Computational Physics. (May 2018) See <https://arxiv.org/abs/1805.06607>.
- 2018 A Fast Algorithm for Quadrature by Expansion in Three Dimensions.
M. Wala, A. Klöckner
Submitted to Journal of Computational Physics. (May 2018) See <https://arxiv.org/abs/1805.06106>.
- 2018 High-order Finite Element–Integral Equation Coupling for Elliptic Problems on Embedded Meshes.
N. N. Beams, A. Klöckner, L. N. Olson
Submitted to Journal of Computational Physics. (April 2018) See <https://arxiv.org/abs/1804.02736>.
- 2018 Conformal Mapping via a Density Correspondence for the Double-Layer Potential.
M. Wala, A. Klöckner
Submitted to SIAM Journal on Scientific Computing. (March 2018) See <https://arxiv.org/abs/1602.04855>.

- 2018 A Fast Algorithm with Error Bounds for Quadrature by Expansion.
M. Wala, A. Klöckner
Accepted in Journal of Computational Physics. (May 2018) See <https://arxiv.org/abs/1801.04070>.
- 2017 Fast algorithms for Quadrature by Expansion I: Globally valid expansions.
M. Rachh, A. Klöckner, M. O’Neil
Journal of Computational Physics, Volume 345, pp. 706-731, Elsevier. (September 2017) Available at doi:10.1016/j.jcp.2017.04.062.
- 2014 Visualizing Skin Effects in Conductors with MRI: ^7Li MRI Experiments and Calculations.
A. Ilott, S. Chandrashekar, A. Klöckner, H. J. Chang, N. Trease, C. Grey, L. Greengard, A. Jerschow
J. Magn. Res., Volume 2014, pp. 143–149. (July 2014) Available at doi:10.1016/j.jmr.2014.06.013.
- 2013 On the convergence of local expansions of layer potentials.
C. Epstein, L. Greengard, A. Klöckner
SIAM Journal on Numerical Analysis, Volume 51, Issue 5, pp. 2660–2679. (2013) Available at doi:10.1137/120902859.
- 2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials.
A. Klöckner, A. Barnett, L. Greengard, M. O’Neil
Journal of Computational Physics, Volume 252, pp. 332-349. (November 2013) Available at doi:10.1016/j.jcp.2013.06.027.
- 2012 A consistency condition for the vector potential in multiply-connected domains.
C. Epstein, Z. Gimbutas, L. Greengard, A. Klöckner, M. O’Neil
IEEE Transactions on Magnetics, Volume 49, Issue 3. (2012) Available at doi:10.1109/TMAG.2012.2223480.
- 2012 PyCUDA and PyOpenCL: A Scripting-Based Approach to GPU Run-Time Code Generation.
A. Klöckner, N. Pinto, Y. Lee, B. Catanzaro, P. Ivanov, A. Fasih
Parallel Computing, Volume 38, Issue 3, pp. 157–174. (March 2012) Available at doi:10.1016/j.parco.2011.09.001.
- 2011 Solving Wave Equations on Unstructured Geometries.
A. Klöckner, T. Warburton, J. S. Hesthaven
GPU Computing Gems “Jade Edition”, Morgan Kaufmann Publishers, Waltham, MA. (2011) Available at doi:10.1016/B978-0-12-385963-1.00018-6.
- 2011 GPU Scripting and Code Generation with PyCUDA.
A. Klöckner, N. Pinto, Y. Lee, B. Catanzaro, P. Ivanov, A. Fasih
GPU Computing Gems “Jade Edition”, Morgan Kaufmann Publishers, Waltham, MA. (2011) Available at doi:10.1016/B978-0-12-385963-1.00027-7.
- 2011 Viscous Shock Capturing in a Time-Explicit Discontinuous Galerkin Method.
A. Klöckner, T. Warburton, J. S. Hesthaven
Mathematical Modelling of Natural Phenomena, Volume 6, Issue 3. (2011) Available at doi:10.1051/mmnp/20116303.

- 2009 Nodal Discontinuous Galerkin Methods on Graphics Processors.
A. Klöckner, *T. Warburton, J. Bridge, J. S. Hesthaven*
Journal of Computational Physics, Volume 228, Issue 21. (November 2009)
Available at doi:10.1016/j.jcp.2009.06.041.

Conference Proceedings (Peer-Reviewed)

- 2016 Array Program Transformation with Loo.py by Example: High-Order Finite Elements.
A. Klöckner, *L. C. Wilcox, T. Warburton*
Proceedings of ARRAY 2016: ACM SIGPLAN Workshop on Libraries, Languages, and Compilers for Array Programming, Santa Barbara, CA, Association for Computing Machinery. (June 2016) Available at doi:10.1145/2935323.2935325.
- 2015 Loo.py: From Fortran to performance via transformation and substitution rules.
A. Klöckner
Proceedings of ARRAY 2015: ACM SIGPLAN Workshop on Libraries, Languages, and Compilers for Array Programming, Portland, OR, Association for Computing Machinery. (June 2015) Available at doi:10.1145/2774959.2774969.
- 2014 Loo.py: transformation-based code generation for GPUs and CPUs.
A. Klöckner
Proceedings of ARRAY 2014: ACM SIGPLAN Workshop on Libraries, Languages, and Compilers for Array Programming, Edinburgh, UK, Association for Computing Machinery. (June 2014) Available at doi:10.1145/2627373.2627387.
- 2012 High-Order Discontinuous Galerkin Methods by GPU Metaprogramming.
A. Klöckner, *T. Warburton, J. S. Hesthaven*
Proceedings of the 2010 Workshop of GPU Solutions to Multiscale Problems in Science and Engineering, Harbin, China, Springer. (2012) See <https://arxiv.org/abs/1211.0582> and <http://books.google.com/books?vid=9783642164040>.
- 2011 A Common GPU n -Dimensional Array for Python and C.
F. Bastien, A. Bergeron, A. Klöckner, P. Vincent, Y. Bengio
Proceedings of the Workshop “Big Learning: Algorithms, Systems, and Tools for Learning at Scale” at NIPS 2011. (2011) See <http://www.iro.umontreal.ca/~lisa/publications2/index.php/publications/show/522>.

Conference Proceedings (Other)

- 2012 Tools and Methods for Discontinuous Galerkin Solvers on Modern Computer Architectures.
A. Klöckner, T. Warburton, J. S. Hesthaven
Proceedings of the 2012 Oberwolfach Workshop “Theory and Applications of Discontinuous Galerkin Methods” (1208a), Oberwolfach, Germany. (2012)
- 2009 Overcoming Performance Bottlenecks in DG-FEM for EM Problems.
S. Chun, H. Haddar, J. S. Hesthaven, A. Klöckner, T. Warburton, L. Wilcox
Proceedings of 9th International Conference on Mathematical and Numerical Aspects of Wave Propagation, pp. 80–81, Pau, France. (June 2009)

Technical Reports

- 2016 A Unified, Hardware-Fitted, Cross-GPU Performance Model.
J. Stevens, A. Klöckner
Technical report. (2016) See <https://arxiv.org/abs/1604.04997>.
- 2009 Deterministic Numerical Schemes for the Boltzmann Equation.
A. Narayan, A. Klöckner
Brown University Scientific Computing Technical Report, Providence, RI 2009-39. (May 2009) See <https://arxiv.org/abs/0911.3589>.

Research Presentations

- 4/2018 Guaranteed-Accuracy Fast Algorithms for the Evaluation of Layer Potentials using ‘Quadrature by Expansion’. UIC Analysis and Applied Mathematics Seminar. University of Illinois at Chicago. Chicago, IL.
- 4/2018 Guaranteed-Accuracy Fast Algorithms for the Evaluation of Layer Potentials using ‘Quadrature by Expansion’. CSCAMM (Center for Scientific Computation and Mathematical Modeling) Seminar Series. University of Maryland. College Park, MD.
- 10/2017 User Interfaces to Performance: Kernel Transformation with Loopy. Dagstuhl Seminar 17431: ‘Performance Portability in Extreme Scale Computing: Metrics, Challenges, Solutions’. Schloss Dagstuhl – Leibniz-Zentrum für Informatik. Wadern, Germany.
- 10/2017 Guaranteed-Accuracy Fast Algorithms for the Evaluation of Layer Potentials using ‘Quadrature by Expansion’. ICES Seminar. University of Texas. Austin, TX.
- 7/2017 Heterogeneous High-Order DG for Hyperbolic PDEs: Methods and Tools. International Workshop ‘Fast High-Order Discontinuous Galerkin Methods for Future Architectures’ (Sponsored by DFG Priority Programme 1648 SPPEXA). Mathematikon, Universität Heidelberg. Heidelberg, Germany.
- 3/2017 Expansion Mechanisms in ‘Quadrature by Expansion’. Minisymposium 202 - Quadrature Methods for Singular and Nearly Singular Integrals in Integral Equations. SIAM Conference on Computational Science and Engineering 2017. Atlanta, GA.

- 1/2017 Introduction to Singular Quadrature, Simulation of Photonic Metamaterials, and Software Frameworks for IEs. ICERM-HKUST VI-MSS workshop on Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science. Institute of Advanced Study, Hong Kong University of Science and Technology. Hong Kong.
- 12/2016 Fast Evaluation of Layer Potentials using Quadrature by Expansion for Photonics Applications. Workshop “Mathematical and Numerical Modeling in Optics”. Institute for Mathematics and its Applications, University of Minnesota. Minneapolis, MN.
- 7/2016 High Performance with Python: Architectures, Approaches, and Applications (Invited keynote address). 15th Annual Conference on Scientific Computing with Python (SciPy 2016). University of Texas, Austin, TX.
- 7/2016 Describe, Don’t Implement: Declarative Programming for PDE Solvers (Invited keynote address). PDE Software Frameworks (PDESoft) 2016. University of Warwick, UK.
- 6/2016 Array Program Transformation with Loo.py by Example: High-Order Finite Elements. Third ACM SIGPLAN International Workshop on Libraries, Languages, and Compilers for Array Programming (co-located with ACM PLDI). Santa Barbara, CA.
- 2/2016 Loo.py: Heterogeneous Code Generation for Array Computations. Tu@XPACC Weekly Seminar of the Center for the Exascale Simulation of Plasma-Coupled Combustion. University of Illinois At Urbana-Champaign. Urbana, IL.
- 1/2016 Loo.py: Heterogeneous Code Generation for Array Computations. Workshop on Exascale Software Technologies (WEST) 2016. Albuquerque, NM.
- 12/2015 Quadrature By Expansion (Departmental Seminar). Department of Aerospace Engineering, IIT Bombay. Mumbai, India.
- 12/2015 Domain-specific languages to Manycore and GPU: Building High-Performance Tools with Python (Invited keynote address). International Conference on Python for Education and Scientific Computing (SciPy India) ‘15. IIT Bombay. Mumbai, India.
- 12/2015 Loo.py: Status and Progress. Earth System Prediction Capability: Advancing Air-Ocean-Land-Ice Global Coupled Prediction on Emerging Computational Architectures Annual Review Meeting. Arlington, VA.
- 6/2015 Loo.py: From Fortran to Performance via Transformation and Substitution Rules. Second ACM SIGPLAN International Workshop on Libraries, Languages, and Compilers for Array Programming (co-located with ACM PLDI). Portland, OR.
- 4/2015 Quadrature by Expansion. Mathematics Department Colloquium. Baylor University. Waco, TX.
- 3/2015 Fast Algorithms for the Evaluation of Layer Potentials using ‘Quadrature by Expansion’. Minisymposium 151 - Software Components for Integral Equation Methods. SIAM Conference on Computational Science and Engineering 2015. Salt Lake City, UT.
- 11/2014 Loo.py: transformation-based code generation for GPUs and CPUs. Earth System Prediction Capability: Advancing Air-Ocean-Land-Ice Global Coupled Prediction on Emerging Computational Architectures Annual Review Meeting. Boulder, CO.

- 7/2014 Fast algorithms for ‘Quadrature by Expansion’. Minisymposium 142 - Boundary Integral Equations and Their Applications. SIAM Annual Meeting 2014. Chicago, IL.
- 6/2014 High-order coupling of QBX with discontinuous volume discretizations. Minisymposium 6 - High-Performance High-Order Simulation Tools and Techniques. International Conference on Spectral and High Order Methods. Salt Lake City, UT.
- 6/2014 Quadrature by Expansion, plus Python Tools and Techniques for Scientific Computing. Numerical Analysis Seminar. University College. London, UK.
- 6/2014 Loo.py: transformation-based code generation for GPUs and CPUs. ACM SIGPLAN International Workshop on Libraries, Languages, and Compilers for Array Programming (co-located with ACM PLDI). Edinburgh, Scotland.
- 5/2014 Quadrature by Expansion, plus Python Tools and Techniques for Scientific Computing. Department of Applied Mathematics, National Dong Hwa University. Hualien City, Taiwan.
- 5/2014 Bicycles for the Mind: Building High-Performance Tools with Python (Non-plenary keynote address). PyCon APAC 2014. Academia Sinica. Taipei, Taiwan.
- 5/2014 Bicycles for the Mind: Building High-Performance Tools with Python. Tercer Escuela Argentina de GPGPU para Aplicaciones Científicas. Centro Atómico Bariloche, Instituto Balseiro, Universidad Nacional de Cuyo. Bariloche, Argentina.
- 3/2014 Quadrature by Expansion, plus Python Tools and Techniques for Scientific Computing. University of Illinois Computational Science & Engineering Seminar. CSE Program. Urbana, IL.
- 12/2013 Fast Algorithms for Quadrature by Expansion. Integral Equations Methods: Fast Algorithms and Applications. Banff International Research Station for Mathematical Innovation and Discovery. Banff, AB, Canada.
- 11/2013 Quadrature by Expansion. Graduate Seminar on Antennas, Electromagnetics, Optics and Remote Sensing. University of Illinois at Urbana-Champaign. Urbana, IL.
- 4/2013 Computational methods in the age of the Free Flop. Graduate Student and Postdoc Seminar. Courant Institute of Mathematical Sciences. New York, NY.
- 4/2013 Quadrature by Expansion. Waves Seminar. Mathematics Department, New Jersey Institute of Technology. Newark, NJ.
- 4/2013 Python and GPUs. Seminar “Python in Finance”. Bank of America Conference Center/Fountainhead Labs. New York, NY.
- 3/2013 Quadrature by Expansion. Numerical Analysis and Scientific Computing Seminar. Courant Institute of Mathematical Sciences. New York, NY.
- 2/2013 Quadrature by Expansion. Minisymposium 72. SIAM Conference on Computational Science and Engineering 2013. Boston, MA.
- 2/2013 Computational Tools for DG on modern computer architectures. Minisymposium 150. SIAM Conference on Computational Science and Engineering 2013. Boston, MA.

- 2/2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials. Applied Physics and Applied Mathematics Department, Columbia University. New York, NY.
- 2/2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials. CS Special Seminar. Computer Science Department, University of Illinois at Urbana-Champaign. Urbana, IL.
- 2/2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials. Mathematical Modeling and Scientific Computing Seminar. Mathematics Department, Southern Methodist University. Dallas, TX.
- 2/2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials. Special Lecture. Computational and Applied Mathematics Department, Rice University. Houston, TX.
- 1/2013 Robust, Efficient, Accurate: High Order Methods in the Age of the Free Flop. Math Colloquium. Mathematics Department, University of North Carolina at Chapel Hill. Chapel Hill, NC.
- 1/2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials. Numerical Analysis Seminar. Mathematics Department, University of Maryland at College Park. College Park, MD.
- 1/2013 Quadrature by Expansion: A New Method for the Evaluation of Layer Potentials. Analysis, Dynamics, and Applications Seminar. Mathematics Department, University of Arizona. Tucson, AZ.
- 10/2012 GPUs and Python (Invited speaker and panelist). PyData NYC—Conference on big data with Python. New York, NY.
- 10/2012 Quadrature by expansion. Applied Mathematics Seminar. Carolina Center for Interdisciplinary Applied Mathematics, University of North Carolina. Chapel Hill, NC.
- 9/2012 Transformational Programming for time- and frequency-domain EM simulation (Invited plenary talk). SCEE2012—Scientific Computing in Electrical Engineering. ETH Zurich. Zurich, Switzerland.
- 5/2012 Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA. HPC & GPU Supercomputing Group of New York City. New York, NY.
- 4/2012 POP Quadrature: Painless high-order-accurate layer potentials. Applied & Computational Mathematics Seminar. Dartmouth Co. Hanover, NH.
- 3/2012 Loo.py: A Loop Generation Tool for CPUs and GPUs. Oil and Gas High Performance Computing Workshop. Rice University. Houston, TX.
- 2/2012 Tools and Methods for DG on Modern Computer Architectures. Oberwolfach workshop “Theory and Applications of Discontinuous Galerkin Methods”. Mathematisches Forschungsinstitut Oberwolfach. Oberwolfach, Germany.
- 2/2012 High-order DG Wave Propagation on GPUs: Infrastructure and Implementation. Minisymposium 13, organized by Takahiro Katagiri, Toshiyuki Imamura, and Keita Teranishi. SIAM Conference on Parallel Processing for Scientific Computing. Savannah, GA.

- 1/2012 Loo.py—a polyhedral code generator for CPUs and GPUs (lightning talk, invited attendee). Synchronization-reducing and Communication-reducing Algorithms and Programming Models for Large-scale Simulations. Institute for Computational and Experimental Research in Mathematics (ICERM), Brown University. Providence, RI.
- 11/2011 Run-time Code Generation for Heterogeneous Computing: Methods and Applications in High-Order PDE Solvers. Red Raider Minisymposium. Texas Tech University. Lubbock, TX.
- 10/2011 Discontinuous Galerkin, Python, and GPUs: a case study. Workshop ‘Programming of Heterogeneous Systems in Physics’. Universität Jena. Jena, Germany.
- 9/2011 Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA. HPC & GPU Supercomputing Group of New York City. New York, NY.
- 8/2011 Run Time Code Generation for Heterogeneous Computing: Methods and Applications in High-Order PDE solvers. Workshop on CBC Key Topics. Center for for Biomedical Computing, Simula Research Laboratory. Lysaker, Norway.
- 8/2011 Run-time Code Generation for Heterogeneous Computing: Methods and Applications in High-Order PDE Solvers. Workshop ‘GPU Computing Today and Tomorrow’. GPULab, Department for Informatics and Mathematical Modelling, Technical University of Denmark. Lyngby, Denmark.
- 6/2011 Generalized Debye Sources: Computational Aspects on Arbitrary Surfaces. Frontiers in Applied and Computational Mathematics. New Jersey Institute of Technology. Newark, NJ.
- 5/2011 Discontinuous Galerkin, Python, and GPUs: the ‘hedge’ solver package. Advances and Challenges in Computational General Relativity. Brown University. Providence, RI.
- 3/2011 High-order DG Wave Propagation on GPUs: Infrastructure, Implementation, Method Improvements. Scientific Computing and Numerics (SCAN) Seminar. Cornell University. Ithaca, NY.
- 3/2011 Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA. Research Seminar. D.E. Shaw Research. New York, NY.
- 3/2011 High-order DG Wave Propagation on GPUs: Infrastructure, Implementation, Method Improvements. Mechanical Engineering Department, City College of New Yew York. New York, NY.
- 3/2011 Shock Capturing in a Time-Explicit Discontinuous Galerkin Method on the GPU. Minisymposium 116. SIAM Conference on Computational Science and Engineering 2011. Reno, NV.
- 3/2011 Paper to GPU: Optimizing and Executing Discontinuous Galerkin Operators in Python. Minisymposium 62. SIAM Conference on Computational Science and Engineering 2011. Reno, NV.
- 3/2011 High-Order Discontinuous Galerkin Methods by GPU Metaprogramming. Minisymposium 1. SIAM Conference on Computational Science and Engineering 2011. Reno, NV.

- 2/2011 High-order DG Wave Propagation on GPUs: Infrastructure, Implementation, Method Improvements. Math Department Seminar. UMass Dartmouth. Dartmouth, MA.
- 1/2011 High-order DG Wave Propagation on GPUs: Infrastructure, Implementation, Method Improvements. Workshop “High Performance Computing and Emerging Architectures”. Institute for Mathematics and Its Applications, University of Minnesota. Minneapolis, MN.
- 12/2010 Machine-adapted Methods: High-order DG Wave Propagation on GPUs. Imaging and Computing Seminar. Mathematics Department, MIT. Boston, MA.
- 11/2010 Machine-adapted Methods: High-order DG Wave Propagation on GPUs. Numerical Analysis and Scientific Computing Seminar. Courant Institute, NYU. New York, NY.
- 10/2010 PyCUDA: Even Simpler GPU Programming with Python. Nvidia GPU Technology Conference. San Jose, CA.
- 7/2010 High-Order Discontinuous Galerkin Methods by GPU Metaprogramming. 2010 International Workshop of GPU Solutions to Multiscale Problems in Science and Engineering. Harbin, China.
- 7/2010 Machine-adapted Methods: Shock Detection and Capture in GPU-DG. Minisymposium 1. SIAM Annual Meeting 2010. Pittsburgh, PA.
- 3/2010 High-Order Discontinuous Galerkin Methods by GPU Metaprogramming. Aerospace Computational Design Laboratory Seminar. Mechanical Engineering, MIT. Boston, MA.
- 1/2010 High-Order Discontinuous Galerkin Methods by GPU Metaprogramming. Mathematics and Computer Science Division Seminar. Argonne National Laboratory. Chicago, IL.
- 11/2009 GPU metaprogramming using PyCUDA: methods and applications. GPU@BU project launch workshop. Boston University Center for Computational Science. Boston, MA.
- 10/2009 High-Order Discontinuous Galerkin Methods and Loop Generation by GPU Metaprogramming. Seminar Departement Mathematik. Universität Basel. Basel, Switzerland.
- 10/2009 GPU Metaprogramming using PyCUDA: Methods & Applications. Nvidia GPU Technology Conference. San Jose, CA.
- 10/2009 Programming GPUs with PyOpenCL (Tutorial). Bernstein Center for Computational Neuroscience. Freiburg, Germany.
- 8/2009 GPU Metaprogramming Applied to High-Order DG and Loop Generation. Frontiers of Geophysical Simulation. Institute for Mathematics Applied to Geosciences. Boulder, CO.
- 7/2009 GPU Computing: Introduction, Scripting, and Time-domain DG. Advanced Computation Department Seminar. SLAC National Accelerator Laboratory. Menlo Park, CA.
- 5/2009 Scripting for GPUs (feat. Discontinuous Galerkin Time Domain). Hess Corporation. Houston, TX.
- 5/2009 Accelerated Computing (Day-long lecture). HPC Summer Institute. Ken Kennedy Institute for Information Technology, Rice University. Houston, TX.

- 3/2009 High-Productivity Supercomputing: Metaprogramming GPUs. Minisymposium 134. SIAM Conference on Computational Science and Engineering 2009. Miami, FL.
- 3/2009 PyCUDA and PyUblas: Hybrid HPC in Python made easy. Minisymposium 98. SIAM Conference on Computational Science and Engineering 2009. Miami, FL.
- 10/2008 High-Order Unstructured Particle-in-Cell Simulation. Mathematics Department Seminar. Southern Methodist University. Dallas, TX.
- 10/2008 High-Order Unstructured Particle-in-Cell Simulation. Computational & Applied Mathematics Department Seminar. Rice University. Houston, TX.
- 7/2008 Methods for High-Order Unstructured Particle-in-Cell Simulation. Seminar des Instituts für Aerodynamik und Gasdynamik. Uni Stuttgart. Stuttgart, Germany.

Workshops and Guest Lectures

- 6/2016 Building High-Performance Tools with Python (7-hour advanced tutorial). IN2P3 Computing School. École Polytechnique / Laboratoire Leprince-Ringuet / IN2P3. Palaiseau, France.
- 6/2016 Building High-Performance Tools with Python (3-hour introductory tutorial). Journée LoOPS. INRIA Saclay / Réseau Loops. Palaiseau, France.
- 12/2015 Domain-Specific Languages to High Performance: Code Generation and Transformation in Python (2-hour introductory tutorial). International Conference on Python for Education and Scientific Computing (SciPy India) '15. IIT Bombay. Mumbai, India.
- 11/2015 From Description to Code Generation: Building High-Performance Tools in Python (Half-day tutorial – Acceptance rate: 53%. Third-most popular tutorial at SC'15 by registrations, 91 registrants). Supercomputing '15. Austin, TX.
- 10/2014 PyOpenCL Tutorial (Three-hour tutorial). Computational Science and Engineering Training Series. University of Illinois at Urbana-Champaign. Urbana, IL.
- 5/2014 Python, numpy, and PyOpenCL (Six-hour tutorial). Tercer Escuela Argentina de GPGPU para Aplicaciones Científicas. Centro Atómico Bariloche, Instituto Balseiro, Universidad Nacional de Cuyo. Bariloche, Argentina.
- 5/2014 Python, numpy, and PyOpenCL (Six-hour tutorial). Tercer Escuela Argentina de GPGPU para Aplicaciones Científicas. Centro Atómico Bariloche, Instituto Balseiro, Universidad Nacional de Cuyo. Bariloche, Argentina.
- 4/2012 Time-Domain Computational Electromagnetics using Discontinuous Galerkin Methods (Guest lecture). Computational Electromagnetics. Courant Institute. New York, NY.
- 8/2011 Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA (One-day workshop). Simula Research Laboratory. Lysaker, Norway.
- 8/2011 Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA (One-day workshop). GPULab, Department for Informatics and Mathematical Modelling, Technical University of Denmark. Lyngby, Denmark.

- 3/2011 Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA (Guest lecture). CS264: Massively Parallel Computing. Harvard University. Boston, MA.
- 1/2011 GPU programming with PyOpenCL and PyCUDA (4 lectures and labs). Pan-American Advanced Studies Institute (PASI) “Scientific Computing in the Americas: the challenge of massive parallelism”. Universidad Técnica Federico Santa María. Valparaíso, Chile.
- 6/2010 Half-day Tutorial on GPU Computing using PyOpenCL. Conference on Scientific Computing in Python (SciPy 2010). Austin, TX.
- 6/2010 GPU Computing with PyOpenCL (Half-day Tutorial). Conference on Scientific Computing in Python (SciPy 2010). Austin, TX.
- 3/2010 GPU Computing (Guest lecture, COMP150-06 (Introduction to High Performance Computing: Tools and Algorithms)). Tufts University. Boston, MA.
- 3/2010 GPU Computing (Guest lecture, APMA2821: Introduction to High Performance Computing: Tools and Algorithms). Brown University. Providence, RI.
- 10/2009 Scripting GPUs with PyOpenCL. FACETS Code Jam 3. Bernstein Center for Computational Neuroscience, Universität Freiburg. Freiburg, Germany.
- 5/2009 Accelerated Computing: GPUs, Cell, Larabee (day-long lecture). 2009 HPC Summer Institute. Ken Kennedy Institute for Information Technology, Rice University. Houston, TX.

Teaching

- 1/2018 – 5/2018 *Scientific Computing Seminar (CS591MH)*
[<http://go.cs.illinois.edu/cs591mh>]
Computer Science, UIUC, Urbana, IL
- 8/2017 – 12/2017 *Fast Algorithms and Integral Equations (CS598APK)*
[<https://relate.cs.illinois.edu/course/cs598apk-f17>]
Computer Science, UIUC, Urbana, IL
- 1/2017 – 5/2017 *Numerical Methods (CS357)*
[<https://relate.cs.illinois.edu/course/cs357-s17>]
Computer Science, UIUC, Urbana, IL
- 8/2016 – 12/2016 *Numerical Methods (CS357)*
Built up a set of lecture notes for the class, introduced frequent, computer-based ‘examlets’ (every two weeks) to establish and maintain student proficiency. [<https://relate.cs.illinois.edu/course/cs357-f16>]
Computer Science, UIUC, Urbana, IL
- 1/2016 – 5/2016 *Numerical Analysis (CS450)*
Enhanced student experience with interactive, online assignments as well as computer-based exams based on RELATE.
[<https://relate.cs.illinois.edu/course/cs450-s16>]
Computer Science, UIUC, Urbana, IL
- 8/2015 – 12/2015 *Fast Algorithms and Integral Equations (CS598APK)*
Redeveloped earlier topics class with a more practical, algorithmic focus. Added interactive, online assignments based on RELATE.
[<https://relate.cs.illinois.edu/course/cs598apk-f15>]
Computer Science, UIUC, Urbana, IL
- 1/2015 – 5/2015 *Numerical Methods (CS 357)*
Computer Science, UIUC, Urbana, IL
Developed a new numerics class for undergraduate computer science majors. Developed a new learning platform (‘RELATE’), pre-lecture quizzes and videos, auto-graded homework, and in-class activities. (Continued from Fall 2014.)
Listed on ‘list of teachers ranked as excellent by their students’.
[<https://relate.cs.illinois.edu/course/cs357-s15/>]
- 8/2014 – 12/2014 *Numerical Methods (CS 357)*
Computer Science, UIUC, Urbana, IL
[<https://relate.cs.illinois.edu/course/cs357-f14/>]
- 1/2014 – 5/2014 *Numerical Analysis (CS 450)*
Computer Science, UIUC, Urbana, IL
- 8/2013 – 12/2013 *Integral Equations and Fast Methods (CS598AK)*
Developed a new topics class on fast and accurate use of integral equations as a tool in the solution of PDEs. Lecture video available on class web page.
[<http://bit.ly/inteq13>]
Computer Science, UIUC, Urbana, IL
- 9/2012 – 12/2012 *High Performance Computing (with Marsha Berger)*
Redeveloped earlier course in a demonstration-based, interactive format. Lecture video available on class web page. [<http://bit.ly/hpc12>]
Courant Institute, NYU, New York, NY

1/2012 – 5/2012	Undergraduate <i>Discrete Mathematics</i> . Courant Institute, NYU, New York, NY
9/2011 – 12/2011	Undergraduate <i>Discrete Mathematics</i> . Courant Institute, NYU, New York, NY
1/2011 – 5/2011	Undergraduate <i>Discrete Mathematics</i> . Courant Institute, NYU, New York, NY
9/2010 – 12/2010	<i>High Performance Computing</i> (with Marsha Berger) Developed course and taught as an early graduate class. Courant Institute, NYU, New York, NY
3/2005 – 7/2005	Recitation leader for <i>Numerical Analysis for PDEs</i> Universität Karlsruhe, Germany (with Vincent Heuveline)
8/2001 – 12/2001	<i>College Algebra</i> University of North Carolina at Charlotte

Funding

9/15/2017 – 9/14/2022	<i>CAREER: Towards General-Purpose, High-Order Integral Equation Methods for Computer Simulation in Engineering: Analysis, Algorithm Design, and Applications</i> National Science Foundation, Computational Mathematics Program, grant number DMS-1654756. \$400k
12/29/2016 – 5/30/2017	<i>Workshop grant: Virtual Institute for Mathematical and Statistical Sciences (VI-MSS): Integral Equation Methods, Fast Algorithms and Their Applications to Fluid Dynamics and Materials Science.</i> (Two two-week workshops with invited graduate students, one at The Hong Kong University of Science and Technology and another at ICERM, joint with Xiao-Ping Wang and Yang Xiang (both HKUST) and Shidong Jiang (NJIT)) Institute for Computational and Experimental Research in Mathematics (ICERM), Providence, RI.
3/8/2015	<i>Hardware donation</i> to support numerics and HPC research. (One Nvidia K40 GPU) Nvidia Corporation, Santa Clara, CA.
7/15/2015 – 6/30/2018	<i>Transform-to-perform: Languages, algorithms, and code transformations for high-performance FEM</i> National Science Foundation, Computer & Communications Foundations Program, grant number CCF-1524433. (joint with Rob Kirby, Baylor University) \$219k (total award: \$450k)
9/23/2014 – 6/21/2015	<i>A Data Model and a Transformation Vocabulary for Partial Differential Equations</i> Army Research Office STIR grant (under subcontract from Baylor University), contract #32180137-01. (joint with Robert Kirby, Baylor University) \$24k (total award: \$50k)
8/15/2014 – 8/14/2017	<i>Efficient High-Order Parallel Algorithms for Large-Scale Photonics Simulation</i> National Science Foundation, Computational Mathematics Program, grant number DMS-1418961. (lead PI, with Shidong Jiang, NJIT) \$210k (total award: \$360k)

3/1/2014 – 2/28/2019 *Center for Exascale Simulation of Plasma-Coupled Combustion (XPACC)* at the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign.
National Nuclear Security Administration, Department of Energy.
Co-PI (Lead PI: William Gropp, \$16M total award amount)

12/1/2013 – 12/31/2016 *NPS-NRL-Rice-UIUC Collaboration on Navy Atmosphere-Ocean Coupled Models on Many-Core Computer Architectures*
Office of Naval Research grant number N00014-12-1-0117 (co-PI with Lucas Wilcox, Tim Warburton, Frank Giraldo, and Tim Campbell) \$210k (total award: \$1,023k)

2010 *Equipment gift*
Advanced Micro Devices, Inc.

Students

- 10/2017 – 4/2018 Xiaoyu Wei, long-term visitor from the PhD program, Mathematics, Hong Kong University of Science and Technology: *Integral Equation Methods for Material Science and Fast Evaluation of Volume Potentials*.
- 8/2017 – Isuru Fernando, PhD student, Computer Science: *Symbolic Computation for Accelerated Expansion Mechanisms in the Evaluation of Layer Potentials*.
- 8/2017 – Hao Gao, PhD student, Computer Science: *Distributed-Memory Algorithms for the Fast Evaluation of Layer Potentials*.
- 8/2017 – Kaushik Kulkarni, PhD student, Computer Science: *High-Performance Transformation-Based Code Generation for Finite Element Methods*.
- 8/2017 – John Doherty, MS student, Computer Science: *Code Generation for the Vectorized Evaluation of Special Functions*.
- 1/2017 – Bogdan Enache, BS/MS student, Computer Science: *Domain-Specific Languages for High-Order Discontinuous Galerkin Methods*.
- 8/2016 – Joshua Bevan, PhD student, Computer Science: *Fast Evaluation of Volume Potentials*.
- 3/2016 – 8/2017 Natalie Beams, PhD, Mechanical Science and Engineering: *High-order Hybrid Methods Using Green's Functions and Finite Elements*. (co-advised with Luke Olson, Computer Science, UIUC; placement: Postdoctoral Fellow, Department of Computational and Applied Mathematics, Rice University)
- 1/2015 – James Stevens, PhD candidate, Computer Science: *Program Transformation and Performance Modeling for Numerical Weather Prediction*.
- 8/2014 – Shivam Gupta, Undergraduate, Computer Science: *Efficient, topology-based incremental refinement of high-order simplicial meshes*.
- 8/2014 – Cory Mikida, PhD candidate, Aerospace Engineering: *Multi-rate Time Integration for the Large-Scale Simulation of Plasma-Coupled Combustion* (co-advised with Daniel Bodony, Aerospace Engineering)
- 1/2014 – Matt Wala, PhD candidate, Computer Science: *High-order numerical methods for layer potential evaluation*.
- 10/2012 – 9/2013 Alexander Kaiser, MS Thesis: *Computational Experiments in Markov Chain Monte Carlo*. (NYU, New York, NY) (awarded Courant Institute thesis prize for best MS thesis in the math dept.)
- 6/2012 – 9/2012 Michael Tom, Undergraduate Research Project: *Computation of Harmonic Vector Fields by High-Order Integral Equation Methods*. (Visiting NYU from Harvard University, Boston, MA)
- 4/2009 – 10/2009 Andreas Stock, Master's Thesis: *Development and Application of a Multirate Multistep AB Method to a Discontinuous Galerkin Method based Particle In Cell Scheme*. (Visiting Brown University from Universität Stuttgart, Germany)
- 4/2009 – 10/2009 Hendrik Riedmann, Project Thesis (“Studienarbeit”): *Efficient Numerical Treatment of the Compressible Navier-Stokes Equations with Nodal Discontinuous Galerkin Methods on Graphics Processors*. (Visiting Brown University from Universität Stuttgart, Germany)

Service

Guest Editor	SIAM Journal on Scientific Computing (Special Section on Software in Computational Science and Engineering in conjunction with SIAM CSE '15)
Organizer	for the following conferences/workshops: <ul style="list-style-type: none">• ARRAY '17 (co-located with PLDI '17), Barcelona, Spain. (co-chairing, joint with David Padua)• Minisymposium 'Computational Science & Numerical Techniques' at SciPy '17, Austin, TX. (co-chairing, joint with Elizabeth Ramirez)• ARRAY '16 (co-located with PLDI '16) (organizing/program committee, joint with Clemens Grelck, Martin Elsman (chairs), and David Padua)• Minisymposia 151, 177, 203, 227: "Software Components for Integral Equation Methods" (joint with Timo Betcke) SIAM conference on Computational Science and Engineering 2015, Salt Lake City, UT.• Minisymposia 72, 89, 121: "Integral Equation Methods in Complex Geometry" (joint with Leslie Greengard) SIAM conference on Computational Science and Engineering 2013, Boston, MA.
Reviewer	for Mathematics and Computers in Simulation (Elsevier), Computer Physics Communications (Elsevier), Journal of Scientific Computing (Springer), Journal of Computational Science (Elsevier), Transactions on Mathematical Software (Association for Computing Machinery), International Journal of High Performance Computing Applications (SAGE Publications), GPU Computing Gems (Nvidia/Morgan Kaufmann), SIAM Journal on Scientific Computing (Society for Industrial and Applied Mathematics), Journal for Computational Physics (Elsevier), International Conference on Spectral and High Order Methods (ICOSAHOM), Communications in Computer Physics (Elsevier), IEEE Transactions on Parallel and Distributed Systems (IEEE), BIT Numerical Mathematics, DOE Advanced Scientific Computing Research (Funding Proposal Solicitation), Journal of Parallel and Distributed Computing (Elsevier).
Panelist	National Science Foundation (2015 and 2017, Arlington, VA)

Program Committee
Member

for the following conferences/workshops:

- Supercomputing 2018 · Programming Systems Track, Dallas, TX
- ARRAY'18 ACM SIGPLAN 5th International Workshop on Libraries, Languages and Compilers for Array Programming, Philadelphia, PA
- PACT 2017 · Parallel Architectures and Compilation Techniques (PACT), Portland, OR
- IMPACT 2017 · 7th International Workshop on Polyhedral Compilation Techniques at HiPEAC '17, Stockholm, Sweden
- PyHPC 2016 at Supercomputing '16, Austin, TX
- Technical Posters Track, Supercomputing '16, Salt Lake City, UT
- PyHPC 2015 at Supercomputing '15, Austin, TX
- IEEE International Conference on High Performance Computing, Data and Analytics (HiPC 2015) (Applications area), Bangalore, India
- ARRAY'15 ACM SIGPLAN 2nd International Workshop on Libraries, Languages and Compilers for Array Programming, Portland, OR
- IEEE International Conference on Parallel and Distributed Systems (ICPADS 2014), track “Multicore Computing and Parallel/Distributed Architecture”, Hsinchu (Taiwan)
- IEEE International Conference on Parallel and Distributed Systems (ICPADS 2012), track “Multicore Computing and Parallel/Distributed Architecture”, Singapore.
- PyHPC 2014 at Supercomputing '14, New Orleans, LA.
- Innovative Parallel Computing (“InPar”) 2012, San Jose, CA.
- 4th Workshop on using Emerging Parallel Architectures (WEPA 2012) held at International Conference on Computational Science (ICCS) 2012, Omaha, NE.
- PyHPC 2011 at Supercomputing '11, Seattle, WA.

Doctoral Committee

Matthew Michelotti (CS, UIUC, '14), Yanhua Sun (CS, UIUC, '15), Huan-ting (Joe) Meng (ECE, UIUC, '15), Pradeep Gudla (MechSE, UIUC, '16), Dhairya Malhotra (ICES, UT Austin, '16), Jian Guan (ECE, UIUC, '17)

Outreach

Faculty Judge for HackIllinois (2015, 2016)

Faculty Advisor

SIAM Student Chapter, University of Illinois at Urbana-Champaign

Member

Society for Industrial and Applied Mathematics, Association for Computing Machinery.

Software Packages

pytential	a software package for the asymptotically fast evaluation of layer potentials, used for the fast solution of boundary value problems for elliptic PDEs. Implements my numerical methods and fast algorithms in two and three dimensions. https://documen.tician.de/pytential
Loopy	a research software package for code generation on heterogeneous architectures. Active collaborations with the DUNE project (U Heidelberg, finite element code generation), Firedrake project (Imperial College, finite element code generation) as well as numerous others including chemical kinetics and neuroscience. https://documen.tician.de/loopy
PyCUDA	a software package to simplify GPU programming in Python. 100th percentile impact among software on the Python package index, according to depsy.org, an NSF-sponsored index of research software impact measures. 10 releases since 8/2013. 450k direct downloads since 6/2008. https://documen.tician.de/pycuda
PyOpenCL	a software package for high-performance scientific computing on heterogeneous architectures, 99th percentile impact among software on the Python package index, according to depsy.org, an NSF-sponsored index of research software impact measures. 18 releases since 8/2013. 320k direct downloads since 8/2009. https://documen.tician.de/pycuda
boxtree	a software package for the shared-memory parallel construction of quadtrees, octrees, associated geometric queries, and interaction traversal structures. https://documen.tician.de/boxtree
meshmode	a software package for the high-order unstructured discretization of surfaces and volumes with complex geometry in one, two, and three dimensions. https://documen.tician.de/meshmode
islpy	a software package for program transformation in the polyhedral model, 95th percentile impact among software on the Python package index, according to depsy.org, an NSF-sponsored index of research software impact measures. 15 releases since 8/2013. 69k direct downloads since 7/2011. https://documen.tician.de/islpy
pymbolic	a software package for program representation, 95th percentile impact among software on the Python package index, according to depsy.org, an NSF-sponsored index of software impact measures. 18 releases since 8/2013. 80k direct downloads since 4/2008. https://documen.tician.de/pymbolic
Relate	Created and continue to maintain RELATE, a course software platform. Used by me for CS 357, CS 450, CS 598 APK. Used by others for CS 101 (since Fall '15), CS 210 (Fall '15), CS 357 (since Fall '15) CS 450 (since Spring '16), CS 555 (Spring '16), CS 556 (Fall '16), CS 491TC (Since Fall '17), CS 446 (Fall '17), CS 196 (Since Fall '17). Open-source and available at https://github.com/inducer/relate , with numerous outside contributions. Known deployments at Zhejiang University, Southern China University of Technology, Universidad Nacional de Colombia. https://documen.tician.de/relate , https://relate.cs.illinois.edu
and numerous others	See https://github.com/inducer .