Curriculum Vitae

Andreas Kloeckner
Courant Institute of Mathematical Sciences
New York University, 251 Mercer St
New York, NY 10012, USA

WWW: http://www.cims.nyu.edu/~kloeckner
Contact: kloeckner@cims.nyu.edu · +1-401-648-0599

Education

2005 – 2010	Ph.D. in Applied Mathematics Division of Applied Mathematics, Brown University, Providence, RI *High-Performance High-Order Simulation of Wave and Plasma Phenomena* *Advisor:* Jan Hesthaven
2005	Diplom degree in Applied Mathematics (Technomathematik) Institut für Angewandte Mathematik, Universität Karlsruhe, Germany *On the Computation of Maximally Localized Wannier Functions* *Advisor:* Willy Dörfler
2001 – 2002	Exchange Student, Department of Mathematics University of North Carolina at Charlotte, Charlotte, NC
2000	Vordiplom in Computer Science, Universität Karlsruhe, Germany

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 Evaluation of Layer Potential Operators. Together with Alexander Barnett and Leslie Greengard, I am investigating a novel scheme to compute Nyström discretizations of layer potential operators and their derivatives for the Helmholtz and Laplace equations at a high order of accuracy. This work includes precise error estimation and automatic adaptivity.

Tools for Scientific Programming. I am pursuing a long-term program to develop a comprehensive set of software tools that supports run-time code generation for CPU and GPU architectures from a high-level programming language. This presents an alternative point of view to commonly accepted software construction practice. The packages Loopy, PyOpenCL, PyCUDA are the main results of this endeavor so far, the latter of which are already seeing wide adoption in industry and academia.

Numerical Methods for Hyperbolic PDEs. Using time-explicit discontinuous Galerkin methods as a starting point, I am investigating problems arising in applications, such as multi-phase flow problems in a Lattice-Boltzmann setting, 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.

Implementation Concerns for DG. Trying to further the computational reach of DG, and at the same time validating my efforts in tool creation, I set out in close collaboration with Tim Warburton to bring DG onto off-the-shelf graphics processors (GPUs). Exploiting DG's special structure allowed us to gain a speed advantage of more than an order of magnitude over the fastest CPU-based DG solvers.

Research Presentations

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.
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	Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA*(guest lecture). CS264, Massively Parallel Computing. Harvard University. Boston, MA.
3/2011	High-order DG Wave Propagation on GPUs: Infrastructure, Implementation, Method Improvements*. Scientific Computing and Numerics (SCAN) Seminar. Cornell University. Ithaca, NY.

*Invited.

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.
1/2011	Easy, Effective, Efficient: GPU programming with PyOpenCL and PyCUDA*. Pan-American Advanced Studies Institute (PASI) "Scientific Computing in the Americas: the challenge of massive parallelism". Universidad Técnica Federico Santa María. Valparaíso, Chile.
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.
6/2010	Half-day Tutorial on GPU Computing using PyOpenCL*. Conference on Scientific Computing in Python (SciPy 2010). Austin, TX.
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	Scripting GPUs with PyOpenCL*. FACETS Code Jam 3. Bernstein Center for Computational Neuroscience, Universität Freiburg. Freiburg, Germany.
10/2009	GPU Metaprogramming using PyCUDA: Methods & Applications*. Nvidia GPU Technology Conference. San Jose, CA.
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: GPUs, Cell, Larabee*(day-long lecture). 2009 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.
1/2009	High-Productivity Supercomputing: Metaprogramming GPUs*(guest lecture). CUDA IAP Class. MIT. Boston, MA.
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.

Teaching

9/2011 – 12/2011	Undergraduate *Discrete Mathematics*. Courant Institute, NYU, New York, NY
8/2011	*Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA*. One-day workshop at Simula Research Laboratory, Lysaker, Norway.

8/2011	*Easy, Effective, Efficient: GPU Programming in Python with PyOpenCL and PyCUDA.* One-day workshop at 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 in CS264, Massively Parallel Computing, Harvard University, Boston, MA, March 2011.
1/2011 – 5/2011	Undergraduate *Discrete Mathematics.* Courant Institute, NYU, New York, NY
1/2011	Course on *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", Valparaíso, Chile
9/2010 – 12/2010	Developed and taught early graduate class on *High Performance Computing* (with Marsha Berger). Courant Institute, NYU, New York, NY
6/2010	Half-day Tutorial on *GPU Computing* using *PyOpenCL.* Conference on Scientific Computing in Python (SciPy 2010), Austin, TX
3/2010	Guest lecture *GPU Computing.* COMP150-06: Introduction to High Performance Computing: Tools and Algorithms. Tufts University, Boston, MA
2/2010	Guest lecture *GPU Computing.* APMA2821: Introduction to High Performance Computing: Tools and Algorithms. Brown University, Providence, RI
10/2009	Tutorial: *Programming GPUs with PyOpenCL.* Bernstein Center for Computational Neuroscience, Freiburg, Germany
5/2009	Day-long lecture: *Accelerated Computing* HPC Summer Institute, Ken Kennedy Institute for Information Technology, Rice University, Houston, TX
2006, 2007	TA for *Computational Linear Algebra* (twice) Brown University, Providence, RI (with Jan Hesthaven)
2006	TA for *Ordinary Differential Equations* Brown University, Providence, RI (with Volker Elling)
3/2005 – 7/2005	Co-TA for *Numerical Methods for PDEs* Universität Karlsruhe, Germany (with Vincent Heuveline)
8/2001 – 12/2001	Instructor for *College Algebra* University of North Carolina at Charlotte

Experience

9/2010 –	Courant Instructor *Courant Institute of Mathematical Sciences, New York University, New York City* Working on integral equation methods for computational electromagnetics (with Leslie Greengard and Zydrunas Gimbutas).

6/2006 – 9/2006	J. Wallace Givens Research Associate *Mathematics and Computer Science Div., Argonne Nat'l Laboratory, Illinois* Worked on high-order unstructured electromagnetic simulation of particle accelerators (with Paul Fischer, Misun Min, and colleagues at ANL's Advanced Photon Source).
2/2005 – 7/2005	Research Associate (Wissenschaftlicher Mitarbeiter) *Institut für Angewandte Mathematik, Universität Karlsruhe, Germany* Worked on various extensions of my thesis research (with Willy Dörfler).
5/2002 – 11/2002	Research Intern *DaimlerChrysler Research & Technology, Palo Alto, CA* Worked on driver stress detection, precision GPS, and software infrastructure (with Stefan Schrödl).

Funding

2011	Consultant on grant proposal "Discontinuous Galerkin Method for Mesoscale Simulation of Liquid Slip on Superhydrophobic/Omniphobic Surfaces" for Taehun Lee (City College of City University of New York) *(pending AFOSR funding decision).*
2011	Consultant on grant proposal "STCI: OpenCL for Scientific Computing" for University of Massachusetts at Dartmouth *(pending NSF funding decision).*

Publications

2012	Layer Potentials by Local Expansion: Fast Evaluation and Analysis. A. Barnett, L. Greengard, C. Epstein, Z. Gimbutas, M. O'Neil, AK *(in preparation)*
2012	Layer Potentials by Local Expansion: Universal Generation of Boundary Integral Quadrature Rules. AK, A. Barnett, L. Greengard, Z. Gimbutas, M. O'Neil *(in preparation)*
2012	Loopy: A Loop Generation Tool for CPUs and GPUs, Part I: Applications and Usage. AK, T. Warburton *(in preparation)*
2012	Loopy: A Loop Generation Tool for CPUs and GPUs, Part II: Data Models, Algorithms, and Heuristics. AK *(in preparation)*
2012	A High-Level, High-Performance Software Architecture for Matrix-Free PDE Solvers. AK *(in preparation)*
2011	A Common GPU n-Dimensional Array for Python and C. Frédéric Bastien, Arnaud Bergeron, AK, Pascal Vincent and Yoshua Bengio *in Proceedings of the Workshop "Big Learning: Algorithms, Systems, and Tools for Learning at Scale" at NIPS 2011.* See `http://www.iro.umontreal.ca/~lisa/publications2/index.php/publications/show/522`

2011	Solving Wave Equations on Unstructured Geometries. AK, T. Warburton, J.S. Hesthaven. *in: GPU Computing Gems "Jade Edition", Morgan Kaufmann Publishers, Waltham, MA*. See `http://books.google.com/books?id=LsNVFUnzcVMC`.
2011	GPU Scripting and Code Generation with PyCUDA. AK, N. Pinto, B. Catanzaro, Y. Lee, P. Ivanov, A. Fasih *in: GPU Computing Gems "Jade Edition", Morgan Kaufmann Publishers, Waltham, MA.* see `http://books.google.com/books?id=LsNVFUnzcVMC`
2011	Viscous Shock Capturing in a Time-Explicit Discontinuous Galerkin Method. AK, T. Warburton, J.S. Hesthaven. *Mathematical Modelling of Natural Phenomena, Volume 6, Issue 3.* Available at doi:10.1051/mmnp/20116303.
2011	PyCUDA and PyOpenCL: A Scripting-Based Approach to GPU Run-Time Code Generation. AK, N. Pinto, Y. Lee, B. Catanzaro, P. Ivanov, and A. Fasih. *Parallel Computing, Volume 38, Issue 3, March 2012, Pages 157—174* Available at doi:10.1016/j.parco.2011.09.001.
2009	Nodal Discontinuous Galerkin Methods on Graphics Processors. AK, T. Warburton, J. Bridge, J.S. Hesthaven. *Journal of Computational Physics, Volume 228, Issue 21, 20 November 2009* available at doi:10.1016/j.jcp.2009.06.041.

Mentoring

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)

Awards and Achievements

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

Software Packages

Hedge	High-performance hybrid Discontinuous Galerkin solver with CPU, GPU and MPI (for both CPU and GPU) backends (MIT licensed)
PyOpenCL	OpenCL programming and metaprogramming in Python (MIT licensed) (More than 35,000 downloads in the last 12 months.)
PyCUDA	CUDA programming and metaprogramming in Python (MIT licensed) (More than 7,000 downloads in the last 12 months.)
and numerous others	such as CodePy, CGen, MeshPy, BoostMPI, PyMetis. See `http://mathema.tician.de/software` for a full list.

Service

Reviewer	for Mathematics and Computers in Simulation (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).
Program Committee Member	for the following conferences/workshops: • IEEE International Conference on Parallel and Distributed Systems (ICPADS 2012), track "Multicore Computing and Parallel/Distributed Architecture", Singapore • Innovative Parallel Computing 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
Member	Society for Industrial and Applied Mathematics.

Citizenship

Germany

References

Available upon request.