

# Hartwig Anzt

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📄 [http://www.icl.utk.edu/~hanzt/index\\_kit.html](http://www.icl.utk.edu/~hanzt/index_kit.html)

## Summary

Hartwig Anzt is a Helmholtz-Young-Investigator Group leader at the Steinbuch Centre for Computing at the Karlsruhe Institute of Technology (KIT). He obtained his PhD in Mathematics at the Karlsruhe Institute of Technology, and afterwards joined Jack Dongarra's Innovative Computing Lab at the University of Tennessee in 2013. Since 2015 he also holds a Senior Research Scientist position at the University of Tennessee. Hartwig Anzt has a strong background in numerical mathematics, specializes in iterative methods and preconditioning techniques for the next generation hardware architectures. His Helmholtz group on Fixed-point methods for numerics at Exascale ("FiNE") is granted funding until 2022. Hartwig Anzt has a long track record of high-quality software development. He is author of the MAGMA-sparse open source software package managing lead and developer of the Ginkgo numerical linear algebra library, and part of the US Exascale computing project delivering production-ready numerical linear algebra libraries.

## Professional Experience

- May 2017 – **Helmholtz Young Investigator Group**, *Karlsruhe Institute of Technology*, Karlsruhe.  
now Steinbuch Centre for Computing (SCC)
- May 2018 – **KIT Associate Fellow**, *Karlsruhe Institute of Technology*, Karlsruhe.  
now
- June 2015 – **Research Scientist**, *University of Tennessee*, Knoxville.  
now Innovative Computing Lab (ICL)
- June 2013 – **PostDoctoral Researcher**, *University of Tennessee*, Knoxville.  
May 2015 Innovative Computing Lab (ICL)
- March 2010 – **Research Associate**, *Karlsruhe Institute of Technology*, Karlsruhe.  
May 2013 Institute for Applied and Numerical Mathematics

## Research Focus

- Algorithm development for resource-efficient computing with particular focus on energy efficiency.
- Design of algorithms for extreme parallelism.
- GPU computing and embedded systems.
- Mixed precision and adaptive precision numerics.
- Sustainable software engineering.
- Algorithms for sparse linear algebra, and data analytics, in particular iterative methods and preconditioners.
- Production-quality Software development
  - Ginkgo library: <https://ginkgo-project.github.io/>
  - MAGMA-sparse library: <http://icl.cs.utk.edu/magma/>
- Energy efficiency in HPC.

## Education

- 2013–2015 **PostDoctoral Researcher**, *University of Tennessee*, Numerical Linear Algebra.
- Nov. 2012 **PhD, Mathematics**, *Asynchronous and Multiprecision Linear Solvers*, Prof. Dr. Vincent Heuveline, Prof. Dr. Jack Dongarra, Prof. Dr. Rudolf Lohner.
- 2010–2012 **PhD Student**, *Karlsruhe Institute of Technology*, Mathematics.

- Dec. 2009 **Dipl. Math.-techn.**, *Hybrid Parallel Solvers for Computational Fluid Dynamics*, Prof. Dr. Vincent Heuveline, Jun.-Prof. Dr. Jan-Philipp Weiss.
- 2008–2009 **Graduate Student**, *University of Karlsruhe*, Mathematics, Physics, Computer Science.
- 2007–2008 **Graduate Student**, *University of Ottawa, CA*, Mathematics, Computer Science.
- June 2006 **Prediploma**, *University of Karlsruhe*.
- 2004–2006 **Student**, *University of Karlsruhe*, Mathematics, Physics, Computer Science.

## Professional Activities

### Program Committee

- Workshop organizer: **Workshop on Scalable Data Analytics in Scientific Computing (SDASC)** at ISC High Performance 2019, <https://sdasconf.github.io/>
- Session organizer: **Scientific Computing** at GAMM 2019, <https://jahrestagung.gamm-ev.de/index.php/2019/2019-scientific-program/2019-timetable>

### Program Committee

- Platform for Advanced Scientific Computing (PASC)
- International Workshop on Parallel Matrix Algorithms and Applications (PMAA)
- International Conference on Computational Science (ICCS)
- Workshop on Latest Advances in Scalable Algorithms for Large-Scale Systems (ScaLA)
- International European Conference on Parallel and Distributed Computing (EuroPar)
- Spring Simulation Multi-Conference (SpringSim)

### Journal Reviews

- SIAM Journal on Scientific Computing (SISC)
- Transactions on Parallel and Distributed Systems (TPDS)
- Parallel Computing (ParCO)
- Journal of Parallel and Distributed Computing (JPDC)
- International Journal of High Performance Computing and Applications (IJHPCA)
- Transactions on Mathematical Software (ACM TOMS)
- Concurrency and Computation: Practice and Experience (CCPE)
- Computer Physics Communications (CPC)
- Numerical Algorithms
- Journal of Computational Science (JoCS)

### Memberships

- Member of the IEEE Society
- Member of the Society of Industrial and Applied Mathematics (SIAM)
- ACM SIGHPC Regional Group Middle Tennessee

## Teaching Experience

- 2019 **Efficient numerical simulation on multi- and manycore processors**, *Invited Lecture*, Friedrich-Alexander University of Erlangen-Nuremberg.
- 2018 **Numerical Linear Algebra for Scientific High Performance Computing**, *LV 0110650*, Karlsruhe Institute of Technology.
- 2018 **Scientific Computing and Machine Learning on Multi- and Manycore Architectures**, *2018 NCTS Short Course*, National Taiwan University.
- 2017 **Numerical Linear Algebra for Scientific High Performance Computing**, *LV 0110650*, Karlsruhe Institute of Technology.
- 2017 **Scientific Computing for Engineers**, *COSC 594 - 005*, University of Tennessee, Knoxville.

- 2016 **Scientific Computing for Engineers**, *COSC 594 - 005*, University of Tennessee, Knoxville.
- 2015 **Introduction to High Performance Computing**, *Invited Lecture*, Georgia Institute of Technology.
- 2015 **Scientific Computing for Engineers**, *COSC 594 - 005*, University of Tennessee, Knoxville.
- 2012 **Module 1 of Certificate for University Teaching (HDZ-Certificate)**, 2012.
- 2010 **Optimal Control for Partial Differential Equations**, **Teaching Assistant**, *Karlsruhe Institute of Technology*.
- 2007 **Linear Algebra II**, **Teaching Assistant**, *Karlsruhe Institute of Technology*.
- 2006 **Linear Algebra I**, **Teaching Assistant**, *Karlsruhe Institute of Technology*.

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## Projects and Project Proposals

- 2019 **[submitted] PI in International Excellence Project**, *A Sustainable Ecosystem for Modular Precision Applications (SEMPA)*, Baden-Württemberg Stiftung.
- 2018 **[submitted] PI in ERC Starting Grant (ERC-ST)**, *A Modular Precision Ecosystem for the Next Generation Digital Processing (ModuPrEc)*, European Research Council, European Union.
- 2018 **[submitted] PI in DFG project**, *Neural Networks for efficiently generating the Sparsity Pattern of matrix-based Preconditioners*, Deutsche Forschungsgemeinschaft.
- 2017 **PI in Helmholtz Young Investigator Group (HYIG)**, *Fixed-Point Methods for Numerics at Exascale (FiNE)*, (volume €1.5M), Helmholtz Foundation, Karlsruhe Institute of Technology (KIT).
- 2016 **PI in Swiss National Supercomputing Centre (CSCS) Small Development Project**, *Energy-Efficient preconditioning for iterative linear solvers*, Swiss National Supercomputing Centre (Lugano), University of Tennessee (Knoxville).
- 2015 **[rejected] PI in ERC Starting Grant (ERC-ST)**, *Asynchronous Fixed-Point Algorithms for efficient High-Performance Computing (ASYNC2HPC)*, European Research Council, European Union.
- 2016 **Co-PI in US Exascale Computing Project**, *Production-ready, Exascale-Enabled, Krylov Solvers (PEEKs) for Exascale Computing*, (volume \$ 280K), Sandia National Laboratories (Albuquerque), University of Tennessee (Knoxville).
- 2016 **Co-PI in US Department of Energy Project**, *Asynchronous Iterative Solvers for Extreme-Scale Computing*, (volume \$ 450K), Georgia Institute of Technology (Atlanta), Sandia National Laboratories (Albuquerque), University of Tennessee (Knoxville), Temple University (Philadelphia).
- 2013 **Investigator in US Department of Energy Project**, *EASIR (Extreme-scale Algorithms and Solver Resilience)*, Sandia National Laboratories (Albuquerque), University of Tennessee (Knoxville), Oak Ridge National Laboratory (Oak Ridge), University of Illinois (Illinois), University of California Berkeley, (Berkeley).
- 2012 **Proposal contribution to FP7 Project (Information and Communication Technologies, Collaborative Project) funded by European Commission**, *Energy-Aware Sustainable Computing on Future Technology – Paving the Road to Exascale Computing (EXA2GREEN)*, Steinbeiss Zentrum (Germany), University of Hamburg (Germany), University Jaime I (Spain), ETH Zurich / Swiss National Supercomputing Centre, IBM Research (Zurich).
- 2012 **Co-PI in Startup-Project funded by KIT**, *Data Compression für Heterogeneous High-Throughput Systems*, Project Partners: Matthias Vogelgesang, KIT.

- 2011 **PI in Startup-Project funded by KIT**, *An embedded Power-measurement System for energy-efficient High Performance Computing*, Project Partners: Dr. Andreas Kopmann, KIT.

### Extended Research Visits

- Jan 2018 **National Taiwan University**, Prof. Weichung Wang.
- Dec 2016 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Jan 2016 **Computing Center Erlangen-Nuermberg (RRZE), Erlangen**, Prof. Gerhard Wellein.
- Jan 2016 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Nov 2015 **L'Institut National de Recherche en Informatique et en Automatique (INRIA), Paris**, Prof. Marc Baboulin.
- Oct 2015 **School of Computational Science and Engineering, Georgia Institute of Technology**, Prof. Edmond Chow.
- Sep 2015 **Max Planck Institute for Dynamics of Complex Technical Systems, Magdeburg**, Prof. Peter Benner.
- Jun 2015 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Dec 2014 **School of Computational Science and Engineering, Georgia Institute of Technology**, Prof. Edmond Chow.
- Aug 2014 **School of Computational Science and Engineering, Georgia Institute of Technology**, Prof. Edmond Chow.
- Apr 2013 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Feb 2013 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Jan 2012 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Sep-Dec 2011 **Innovative Computing Laboratory, University of Tennessee, Knoxville**, Prof. Jack Dongarra.
- Mar 2011 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.
- Nov 2010 **Depto. de Ingeniería y Ciencia de Computadores, University Jaime I**, Prof. Enrique S. Quintana-Ortí.

### Scientific Metrics

- Citations **700**, (*Google Scholar, January 2019*).
- h-index **16**, (*Google Scholar, August 2018*).
- i10-index **31**, (*Google Scholar, August 2018*).

### Recent Invited Talks

- 2018 **Towards a Modular Precision Ecosystem**, *Seminar talk at the University of the Republic Uruguay 2018, Uruguay*.
- 2018 **Towards a Modular Precision Ecosystem**, *Workshop on Clusters, Clouds, and Data for Scientific Computing (CCDC) 2018, Lyon*.

- 2018 **Fixed-Point and Mixed-Precision Methods for Numerics at Exascale**, *GridKa Workshop 2018, Karlsruhe*.
- 2018 **Numerical Linear Algebra for High Performance Computing**, *SBD Workshop: Transfer of HPC and Data Know-How to Scientific Communities, 2018, Juelich*.
- 2018 **ParILUT - a new parallel threshold ILU**, *SIAM PP2018, Tokyo*.
- 2017 **Computing more for saving energy?**, *Workshop on Power-Aware Computing, PACO 2017, Tegernsee*.
- 2017 **Batched Factorization and Inversion Routines for Block-Jacobi Preconditioning on GPUs**, *Platform for Advanced Scientific Computing, PASC 2017, Lugano*.
- 2017 **Linear Algebra Software for High Performance Computing**, *Tutorial at International Conference on Supercomputing, ISC 2017, Frankfurt*.
- 2017 **Feeding of the Thousands – Batched Routines for Many-Core Programming**, *Parallel 2017, Heidelberg*.
- 2017 **Batched Factorization and Inversion Routines for Block-Jacobi Preconditioning on GPUs**, *Workshop on Batched, Reproducible, and Reduced Precision BLAS, Atlanta*.
- 2017 **Preconditioning on Parallel and Hybrid Architectures**, *SIAM Conference on Computational Science & Engineering, SIAM CSE 2017, Atlanta*.

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## Peer-Reviewed Publications

- [1] Hartwig Anzt, Edmond Chow, and Jack Dongarra. ParILUT—A New Parallel Threshold ILU Factorization. *SIAM Journal on Scientific Computing*, 40(4):C503–C519, 2018.
- [2] Hartwig Anzt, Jack Dongarra, Goran Flegar, Nicholas J. Higham, and Enrique S. Quintana-Ortí. Adaptive precision in block-Jacobi preconditioning for iterative sparse linear system solvers. *Concurrency and Computation: Practice and Experience*, 0(0):e4460, 2018. e4460 cpe.4460.
- [3] Hartwig Anzt, Jack Dongarra, Goran Flegar, and Enrique S. Quintana-Ortí. Variable-size batched gauss–jordan elimination for block-jacobi preconditioning on graphics processors. *Parallel Computing*, 2018.
- [4] Hartwig Anzt, Thomas K. Huckle, Jürgen Bräckle, and Jack Dongarra. Incomplete sparse approximate inverses for parallel preconditioning. *Parallel Computing*, 71(Supplement C):1 – 22, 2018.
- [5] Hartwig Anzt, Moritz Kreutzer, Eduardo Ponce, Gregory D Peterson, Gerhard Wellein, and Jack Dongarra. Optimization and performance evaluation of the idr iterative krylov solver on gpus. *The International Journal of High Performance Computing Applications*, 32(2):220–230, 2018.
- [6] Edmond Chow, Hartwig Anzt, Jennifer Scott, and Jack Dongarra. Using jacobi iterations and blocking for solving sparse triangular systems in incomplete factorization preconditioning. *Journal of Parallel and Distributed Computing*, 119:219 – 230, 2018.
- [7] Thomas Grützmacher and Hartwig Anzt. A modular precision format for decoupling arithmetic format and storage format. In *Euro-Par 2018: Parallel Processing Workshops - Euro-Par 2018 International Workshops, Turin, Italy, August 27-28, 2018, Revised Selected Papers*, pages 434–443, 2018.
- [8] J. Dongarra, S. Tomov, P. Luszczek, J. Kurzak, M. Gates, I. Yamazaki, H. Anzt, A. Haidar, and A. Abdelfattah. With extreme computing, the rules have changed. *Computing in Science Engineering*, 19(3):52–62, May 2017.

- [9] H. Anzt, J. Dongarra, M. Gates, J. Kurzak, P. Luszczek, S. Tomov, and I. Yamazaki. Bringing high performance computing to big data algorithms. pages 777–806, 2017.
- [10] Hartwig Anzt, Marc Baboulin, Jack Dongarra, Yvan Fournier, Frank Hulsemann, Amal Khabou, and Yushan Wang. Accelerating the conjugate gradient algorithm with gpus in cfd simulations. pages 35–43, 2017.
- [11] Hartwig Anzt, Gary Collins, Jack Dongarra, Goran Flegar, and Enrique S. Quintana-Ortí. Flexible batched sparse matrix-vector product on gpus. In *Proceedings of the 8th Workshop on Latest Advances in Scalable Algorithms for Large-Scale Systems, ScalA '17*, pages 3:1–3:8, New York, NY, USA, 2017. ACM.
- [12] Hartwig Anzt, Jack Dongarra, Goran Flegar, and Enrique S. Quintana-Ortí. Batched gauss-jordan elimination for block-jacobi preconditioner generation on gpus. In *Proceedings of the 8th International Workshop on Programming Models and Applications for Multicores and Manycores, PMAM'17*, pages 1–10, New York, NY, USA, 2017. ACM.
- [13] Hartwig Anzt, Jack Dongarra, Goran Flegar, and Enrique S. Quintana-Ortí. Variable-Size Batched LU for Small Matrices and Its Integration into Block-Jacobi Preconditioning. In *2017 46th International Conference on Parallel Processing (ICPP)*, pages 91–100, 2017.
- [14] Hartwig Anzt, Jack Dongarra, Goran Flegar, Enrique S. Quintana-Ortí, and Andrés E. Tomás. Variable-Size Batched Gauss-Huard for Block-Jacobi Preconditioning. *Procedia Computer Science*, 108:1783 – 1792, 2017. International Conference on Computational Science, {ICCS} 2017, 12-14 June 2017, Zurich, Switzerland.
- [15] Hartwig Anzt, Mark Gates, Jack Dongarra, Moritz Kreutzer, Gerhard Wellein, and Martin Köhler. Preconditioned Krylov solvers on GPUs. *Parallel Computing*, 68:32–44, 2017. Applications for the Heterogeneous Computing Era.
- [16] Goran Flegar and Hartwig Anzt. Overcoming load imbalance for irregular sparse matrices. In *Proceedings of the Seventh Workshop on Irregular Applications: Architectures and Algorithms, IA3'17*, pages 2:1–2:8, New York, NY, USA, 2017. ACM.
- [17] Hartwig Anzt, Jack Dongarra, Moritz Kreutzer, Gerhard Wellein, and Markus Koehler. Efficiency of general krylov methods on gpus – an experimental study. In *2016 IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW)*, pages 683–691, May 2016.
- [18] A. Abdelfattah, H. Anzt, J. Dongarra, M. Gates, A. Haidar, J. Kurzak, P. Luszczek, S. Tomov, I. Yamazaki, and A. YarKhan. Linear algebra software for large-scale accelerated multicore computing. *Acta Numerica*, 25:1–160, 5 2016.
- [19] Hartwig Anzt, Edmond Chow, and Jack Dongarra. On block-asynchronous execution on GPUs. Technical Report 291, LAPACK Working Note, 2016.
- [20] Hartwig Anzt, Edmond Chow, Thomas Huckle, and Jack Dongarra. Batched Generation of Incomplete Sparse Approximate Inverses on GPUs. In *Proceedings of the 7th Workshop on Latest Advances in Scalable Algorithms for Large-Scale Systems, ScalA '16*, pages 49–56, 2016.
- [21] Hartwig Anzt, Edmond Chow, Jens Saak, and Jack Dongarra. Updating Incomplete Factorization Preconditioners for Model Order Reduction. *Numerical Algorithms*, 73(3):611–630, 2016.
- [22] Hartwig Anzt, Edmond Chow, Daniel B. Szyld, and Jack Dongarra. Domain Overlap for Iterative Sparse Triangular Solves on GPUs. In Hans-Joachim Bungartz, Philipp Neumann,

- and Wolfgang E. Nagel, editors, *Software for Exascale Computing - SPPEXA*, volume 113 of *Lecture Notes in Computer Science and Engineering*, pages 527–545. Springer International Publishing, 2016.
- [23] Hartwig Anzt, Jack Dongarra, and Enrique S. Quintana-Ortí. Fine-grained Bit-Flip Protection for Relaxation Methods. *Journal of Computational Science*, 2016.
- [24] Hartwig Anzt, Stanimire Tomov, and Jack Dongarra. On the performance and energy efficiency of sparse linear algebra on GPUs. *International Journal of High Performance Computing Applications*, 2016.
- [25] C. J. Newburn, G. Bansal, M. Wood, L. Crivelli, J. Planas, A. Duran, P. Souza, L. Borges, P. Luszczek, S. Tomov, Jack Dongarra, H. Anzt, M. Gates, A. Haidar, Y. Jia, K. Kabir, I. Yamazaki, and J. Labarta. Heterogeneous streaming. In *2016 IEEE International Parallel and Distributed Processing Symposium Workshops, IPDPS Workshops 2016, Chicago, IL, USA, May 23-27, 2016*, pages 611–620, 2016.
- [26] Edmond Chow, Hartwig Anzt, and Jack Dongarra. Asynchronous Iterative Algorithm for Computing Incomplete Factorizations on GPUs. In *Lecture Notes in Computer Science*, volume 9137, pages 1–16, July 12 – 16 2015.
- [27] J. I. Aliaga, H. Anzt, M. Castillo, J. C. Fernández, G. León, J. Pérez, and E. S. Quintana-Ortí. Unveiling the performance-energy trade-off in iterative linear system solvers for multithreaded processors. *Concurrency and Computation: Practice and Experience*, 27(4):885–904, 2015.
- [28] H. Anzt, W. Sawyer, S. Tomov, P. Luszczek, and J. Dongarra. Acceleration of GPU-based Krylov solvers via Data Transfer Reduction. *International Journal of High Performance Computing*, 2015.
- [29] Hartwig Anzt, Edmond Chow, and Jack Dongarra. Iterative sparse triangular solves for preconditioning. In Jesper Larsson Träff, Sascha Hunold, and Francesco Versaci, editors, *Euro-Par 2015: Parallel Processing*, volume 9233 of *Lecture Notes in Computer Science*, pages 650–661. Springer Berlin Heidelberg, 2015.
- [30] Hartwig Anzt, Jack Dongarra, and Enrique S. Quintana-Ortí. Adaptive Precision Solvers for Sparse Linear Systems. In *Proceedings of the 3rd International Workshop on Energy Efficient Supercomputing, E2SC '15*, pages 2:1–2:10, New York, NY, USA, 2015. ACM.
- [31] Hartwig Anzt, Jack Dongarra, and Enrique S. Quintana-Ortí. Tuning Stationary Iterative Solvers for Fault Resilience. In *Proceedings of the 6th Workshop on Latest Advances in Scalable Algorithms for Large-Scale Systems, ScalA '15*, pages 1:1–1:8, New York, NY, USA, 2015. ACM.
- [32] Hartwig Anzt, Blake Haugen, Jakub Kurzak, Piotr Luszczek, and Jack Dongarra. Experiences in autotuning matrix multiplication for energy minimization on GPUs. *Concurrency and Computation: Practice and Experience*, 27(17):5096–5113, 2015.
- [33] Hartwig Anzt, Eduardo Ponce, Gregory D. Peterson, and Jack Dongarra. GPU-accelerated Co-design of Induced Dimension Reduction: Algorithmic Fusion and Kernel Overlap. In *Proceedings of the 2Nd International Workshop on Hardware-Software Co-Design for High Performance Computing, Co-HPC '15*, pages 5:1–5:8, New York, NY, USA, 2015. ACM.
- [34] Hartwig Anzt, Stanimire Tomov, and Jack Dongarra. Accelerating the LOBPCG method on GPUs using a blocked Sparse Matrix Vector Product. In *Spring Simulation Multi-Conference 2015 (SpringSim '15)*, 2015.
- [35] Hartwig Anzt, Stanimire Tomov, and Jack Dongarra. Energy Efficiency and Performance Frontiers for Sparse Computations on GPU Supercomputers. In *Proceedings of the Sixth*

- International Workshop on Programming Models and Applications for Multicores and Manycores*, PMAM '15, pages 1–10, New York, NY, USA, 2015. ACM.
- [36] Mark Gates, Hartwig Anzt, Jakub Kurzak, and Jack Dongarra. Accelerating Collaborative Filtering Using Concepts from High Performance Computing. In *IEEE International Conference on Big Data*, 2015.
- [37] Jakub Kurzak, Hartwig Anzt, Mark Gates, and Jack Dongarra. Implementation and Tuning of Batched Cholesky Factorization and Solve for NVIDIA GPUs. *IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS*, 27(7):2036–2048, 2015.
- [38] J. I. Aliaga, H. Anzt, M. Castillo, J. Fernández, G. Leó, J. Perez, and E. S. Quintana-Ortí. Performance and Energy Analysis of the Iterative Solution of Sparse Linear Systems on Multicore and Manycore Architectures. In *Lecture Notes in Computer Science*, volume 8384, 2014.
- [39] H. Anzt, A. Beglarian, S. Chilingaryan, A. Ferrone, V. Heuveline, and A. Kopmann. A unified energy footprint for simulation software. *Computer Science - Research and Development*, 29(2):131–138, 2014.
- [40] Hartwig Anzt, Dimitar Lukarski, Stanimire Tomov, and Jack Dongarra. Self-Adaptive Multiprecision Preconditioners on Multicore and Manycore Architectures. In *11th International Meeting on High Performance Computing for Computational Science, VECPAR 2014*, 2014.
- [41] Hartwig Anzt and Enrique S. Quintana-Ortí. Improving the energy efficiency of sparse linear system solvers on multicore and manycore systems. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*, 372(2018), 2014.
- [42] Hartwig Anzt, William Sawyer, Stanimire Tomov, Piotr Luszczek, Ichitaro Yamazaki, and Jack Dongarra. Optimizing Krylov Subspace Solvers on Graphics Processing Units. In *28th IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW 2014)*, 2014.
- [43] Hartwig Anzt, Stanimire Tomov, and Jack Dongarra. Implementing a Sparse Matrix Vector Product for the SELL-C/SELL-C- $\sigma$  formats on NVIDIA GPUs. In *Technical Report*, 2014.
- [44] Dimitar Lukarski, Hartwig Anzt, Stanimire Tomov, and Jack Dongarra. Hybrid Multi-Elimination ILU Preconditioners on GPUs. In *28th IEEE International Parallel and Distributed Processing Symposium Workshops (IPDPSW 2014)*, 2014.
- [45] Ichitaro Yamazaki, Hartwig Anzt, Stanimire Tomov, Mark Hoemmen, and Jack Dongarra. Improving the Performance of CA-GMRES on Multicores with Multiple GPUs. In *28th IEEE International Parallel and Distributed Processing Symposium (IPDPS 2014)*, 2014.
- [46] J.I. Aliaga, J. Perez, E.S. Quintana-Orti, and H. Anzt. Reformulated Conjugate Gradient for the Energy-Aware Solution of Linear Systems on GPUs. In *Parallel Processing (ICPP), 2013 42nd International Conference on*, pages 320–329, Oct 2013.
- [47] Hartwig Anzt, Stanimire Tomov, Jack Dongarra, and Vincent Heuveline. A block-asynchronous relaxation method for graphics processing units. *J. Parallel Distrib. Comput.*, 73(12):1613–1626, 2013.
- [48] Hartwig Anzt. *Asynchronous and Multiprecision Linear Solvers - Scalable and Fault-Tolerant Numerics for Energy Efficient High Performance Computing*. PhD thesis, Karlsruhe Institute of Technology, Institute for Applied and Numerical Mathematics, Nov. 2012.



- [49] H. Anzt, M. Castillo, J. C. Fernández, V. Heuveline, F. D. Igual, R. Mayo, and E. S. Quintana-Ortí. Optimization of power consumption in the iterative solution of sparse linear systems on graphics processors. *Computer Science - R&D*, 27(4):299–307, 2012.
- [50] Hartwig Anzt, Piotr Luszczek, Jack Dongarra, and Vincent Heuveline. GPU-Accelerated Asynchronous Error Correction for Mixed Precision Iterative Refinement. In *Lecture Notes in Computer Science*, volume 7484, pages 908–919. Springer Berlin Heidelberg, 2012.
- [51] Hartwig Anzt, Stanimire Tomov, Jack Dongarra, and Vincent Heuveline. A Block-Asynchronous Relaxation Method for Graphics Processing Units. In *IPDPS Workshops*, pages 113–124. IEEE Computer Society, 2012.
- [52] Hartwig Anzt, Stanimire Tomov, Jack Dongarra, and Vincent Heuveline. Weighted Block-Asynchronous Iteration on GPU-Accelerated Systems. In *Euro-Par Workshops*, volume 7640 of *Lecture Notes in Computer Science*, pages 145–154. Springer, 2012.
- [53] Hartwig Anzt, Stanimire Tomov, Mark Gates, Jack Dongarra, and Vincent Heuveline. Block-asynchronous Multigrid Smoothers for GPU-accelerated Systems. In Hesham H. Ali, Yong Shi, Deepak Khazanchi, Michael Lees, G. Dick van Albada, Jack Dongarra, and Peter M. A. Sloot, editors, *ICCS*, volume 9 of *Procedia Computer Science*, pages 7–16. Elsevier, 2012.
- [54] H. Anzt, V. Heuveline, J. I. Aliaga, M. Castillo, J. C. Fernandez, R. Mayo, and E. S. Quintana-Ortí. Analysis and optimization of power consumption in the iterative solution of sparse linear systems on multi-core and many-core platforms. In *Green Computing Conference and Workshops (IGCC), 2011 International*, pages 1–6, july 2011.
- [55] H. Anzt, W. Augustin, M. Baumann, T. Gengenbach, T. Hahn, A. Helfrich-Schkarbanenko, V. Heuveline, E. Ketelaer, D. Lukarski, A. Nestler, S. Ritterbusch, S. Ronnas, M. Schick, M. Schmidtobreck, C. Subramanian, J.-P. Weiss, F. Wilhelm, and M. Wlotzka. HiFlow<sup>3</sup>: A hardware-aware parallel finite element package. In *Tools for High Performance Computing 2011 - Proceedings of the 5th International Workshop on Parallel Tools for High Performance Computing, ZIH, Dresden, September 2011*, pages 139–151, 2011.
- [56] H. Anzt, W. Augustin, M. Baumann, T. Gengenbach, T. Hahn, A. Helfrich-Schkarbanenko, V. Heuveline, E. Ketelaer, D. Lukarski, A. Nestler, S. Ritterbusch, S. Ronnas, M. Schick, M. Schmidtobreck, C. Subramanian, J.-P. Weiss, F. Wilhelm, and M. Wlotzka. HiFlow3: A Hardware-Aware Parallel Finite Element Package. In *Parallel Tools Workshop*, pages 139–151. Springer, 2011.
- [57] H. Anzt, V. Heuveline, B. Rucker, M. Castillo, J. C. Fernández, R. Mayo, and E. S. Quintana-Ortí. Power Consumption of Mixed Precision in the Iterative Solution of Sparse Linear Systems. In *IPDPS Workshops*, pages 829–836, 2011.
- [58] Hartwig Anzt, Vincent Heuveline, and Björn Rucker. An Error Correction Solver for Linear Systems: Evaluation of Mixed Precision Implementations. In José Palma, Michel Daydé, Osni Marques, and Joao Lopes, editors, *High Performance Computing for Computational Science – VECPAR 2010*, volume 6449 of *Lecture Notes in Computer Science*, pages 58–70. Springer Berlin / Heidelberg, 2011.
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