

# Erin Claire Carson

## Curriculum Vitae

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## Education

- 2009  
2015 Ph.D. in Computer Science, with a Designated Emphasis in Computational and Data Science and Engineering, University of California Berkeley.
- 2005  
2009 B.S. in Computer Science, with Minors in Applied Mathematics and Materials Science, University of Virginia.

## PhD Thesis

- Title *Communication-avoiding Krylov Subspace Methods in Theory and Practice*
- Supervisors Professor James Demmel & Professor Armando Fox
- Description This thesis evaluates tradeoffs between performance and accuracy in communication-avoiding Krylov subspace solvers for high-performance scientific codes.

## Professional Appointments

- 2019  
PRIMUS Research Fellow, Department of Numerical Mathematics, Faculty of Mathematics and Physics, Charles University.
- 2018  
2019 Vědecký Pracovník, Department of Numerical Mathematics, Faculty of Mathematics and Physics, Charles University.
- 2015  
2018 Courant Instructor/Assistant Professor, Courant Institute of Mathematical Sciences, New York University.

## Grants

- 2019  
Principal Investigator of the PRIMUS Research Program “Scalable and Accurate Numerical Linear Algebra for Next-Generation Hardware” (*until September 2022*), Charles University.
- 2020  
Principal Investigator/Subcontractor, DOE Exascale Computing Project - xSDK, “Mixed Precision Numerical Linear Algebra”, Subcontract Award B639388 and B644596, LLNL - Charles University.

## Publications

### Journal Papers

- 2021  
E. Carson, K. Lund, and M. Rozložník, *The Stability of Block Variants of Classical Gram-Schmidt*, SIAM Journal on Matrix Analysis and Applications 42(3), 2021, pp. 1365-1380.
- 2021  
A. Abdelfattah, H. Anzt, E. G. Boman, E. Carson, et al., *A Survey of Numerical Methods Utilizing Mixed Precision Arithmetic*, International Journal of High Performance Computing Applications, 2021.
- 2020  
E. Carson, N. J. Higham, and S. Pranesh, *Three-Precision GMRES-Based Iterative Refinement for Least Squares Problems*, SIAM Journal on Scientific Computing 42(6), 2020, pp. A4063-A4083.
- 2020  
T. Chen and E. Carson, *Predict-and-Recompute Conjugate Gradient Variants*, SIAM Journal on Scientific Computing 42(5), 2020, pp. A3084-A3108.

- 2020 E. Carson, *An Adaptive s-step Conjugate Gradient Algorithm with Dynamic Basis Updating*, Applications of Mathematics 65(2), 2020, pp. 123-151, DOI 10.21136/AM.2020.0136-19.
- 2020 E. Carson and Z. Strakoš, *On the Cost of Iterative Computations*, Philosophical Transactions of the Royal Society A, 378(2166), 2020, DOI 10.1098/rsta.2019.0050.
- 2018 E. Carson, M. Rozložník, Z. Strakoš, P. Tichý, and M. Tůma, *The Numerical Stability Analysis of Pipelined Conjugate Gradient Methods: Historical Context and Methodology*, SIAM Journal on Scientific Computing 40(5), 2018, pp. A3549-3580.
- 2018 E. Carson, *The Adaptive s-step Conjugate Gradient Method*, SIAM Journal on Matrix Analysis and Applications 39(3), 2018, pp. 1318-1338.
- 2018 E. Carson and N. Higham, *Accelerating the Solution of Linear Systems by Iterative Refinement in Three Precisions*, SIAM Journal on Scientific Computing 40(2), 2018, pp. A817-A847 .
- 2017 E. Carson and N. Higham, *A New Analysis of Iterative Refinement and its Application to Accurate Solution of Ill-Conditioned Sparse Linear Systems*, SIAM Journal on Scientific Computing 39(6), 2017, pp. A2834-A2856.
- 2016 E. Solomonik, E. Carson, N. Knight, and J. Demmel, *Tradeoffs between Synchronization, Communication, and Computation in Parallel Linear Algebra Computations*, ACM Transactions on Parallel Computing (TOPC) 3(1), 2016, pp. 3:1-3:47.
- 2015 E. Carson and J. Demmel, *Accuracy of the s-Step Lanczos Method for the Symmetric Eigenproblem in Finite Precision*, SIAM Journal on Matrix Analysis and Applications 36(2), 2015, pp. 793-819.
- 2014 E. Carson, N. Knight, and J. Demmel, *An Efficient Deflation Technique for the Communication-Avoiding Conjugate Gradient Method*, Electronic Transactions on Numerical Analysis 43, 2014, pp. 125-141.
- 2014 G. Ballard, E. Carson, J. Demmel, M. Hoemmen, N. Knight, and O. Schwartz, *Communication Lower Bounds and Optimal Algorithms for Numerical Linear Algebra*, Acta Numerica 23, 2014, pp. 1-155.
- 2014 N. Knight, E. Carson and J. Demmel, *Exploiting Data Sparsity in Parallel Matrix Powers Computations*, in Parallel Processing and Applied Mathematics, R. Wyrzykowski, J. Dongarra, K. Karczewski, and J. Waniewski, eds., Lecture Notes in Computer Science, Springer Berlin Heidelberg, 2014, pp. 15-25.
- 2014 E. Carson and J. Demmel, *A Residual Replacement Strategy for Improving the Maximum Attainable Accuracy of s-Step Krylov Subspace Methods*, SIAM Journal on Matrix Analysis and Applications 35(1), 2014, pp. 22-43.
- 2013 E. Carson, N. Knight, and J. Demmel, *Avoiding Communication in Nonsymmetric Lanczos-based Krylov Subspace Methods*, SIAM Journal on Scientific Computing 35(5), 2013, pp. S42-S61.

## Conference Proceedings

- 2016 Carson, E., Demmel, J., Grigori, L., Knight, N., Koanantakool, P., Schwartz, O. and Simhadri, H.V., *Write-Avoiding Algorithms*, in Proceedings of the 30th IEEE International Parallel and Distributed Processing Symposium, 2016, pp.648-658.
- 2014 E. Solomonik, E. Carson, N. Knight, and J. Demmel, *Tradeoffs Between Synchronization, Communication, and Work in Parallel Linear Algebra Computations*, in Proceedings of the 26th ACM Symposium on Parallelism in Algorithms and Architectures (SPAA), 2014.
- 2014 S. Williams, E. Carson, M. Lijewski, N. Knight, A. Almgren, B. Van Straalen, and J. Demmel, *s-Step Krylov Subspace Methods as Bottom Solvers for Geometric Multigrid*, in Proceedings of the 28th IEEE International Parallel and Distributed Processing Symposium, 2014.
- 2007 J. Carnahan, S. Policastro, E. Carson, P. Reynolds Jr., and R. Kelly, *Using Flexible Points in a Developing Simulation of Selective Dissolution in Alloys*, in Proceedings of the 39th Winter Simulation Conference, IEEE Press, 2007, pp.891-899.

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## Presentations

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- 2021 • “When Floating-Point Error Matters: the Hazards and Challenges of Low-Precision Computation”, SIAM Annual Meeting, online, July 22, 2021.
  - 2021 • “Mixed Precision  $s$ -step Lanczos and Conjugate Gradient Algorithms”, Platform for Advanced Scientific Computing (PASC), online, July 7, 2021.
  - 2021 • **Invited Talk:** “The cost of iterative computations at scale”, Irish Numerical Analysis Forum, online, July 1, 2021.
  - 2021 • “The numerical stability of block classical Gram-Schmidt variants”, SIAM Applied Linear Algebra, online, May 18, 2021.
  - 2021 • **Invited Talk:** “What do we know about block Gram-Schmidt”, E-NLA Seminar, online, February 24, 2021.
  - 2020 • **Invited Talk:** “High Performance Mixed Precision Numerical Linear Algebra”, Cornell Scientific Computing and Numerics (SCAN) Seminar, online, November 9, 2020.
  - 2020 • **Invited Talk:** “High Performance Mixed Precision Numerical Linear Algebra”, KU Leuven Numerical Mathematics (NUMA) Seminar, online, October 29, 2020.
  - 2019 • **Panelist:** “The Road to Exascale and Beyond Is Paved by Software: How Algorithms, Libraries and Tools Will Make Exascale Performance Real”, Supercomputing 2019, November 17-22, 2019.
  - 2019 • **Invited Talk:** “The Cost of Iterative Computations”, Advanced Solvers for Modern Architectures, Muenster, Germany, November 11-13, 2019.
  - 2019 • **Invited Keynote Talk:** “Iterative Refinement in Three Precisions”, PACO 2019: 3rd Workshop on Power-Aware Computing, Magdeburg, Germany, November 5-6, 2019.
  - 2019 • “Iterative Refinement in Three Precisions”, Parallel Solution Methods for Systems Arising from PDEs, Centre International De Rencontres Mathématiques (CIRM), Luminy, France, September 16-20, 2019.
  - 2019 • “On the Amplification of Rounding Errors”, Advances in Numerical Linear Algebra: Celebrating the Centenary of the Birth of James H. Wilkinson, Manchester, UK, May 29-30, 2019.
  - 2019 • **Invited Keynote Talk:** “The Cost of Iterative Computations”, High-Performance Computing in Science and Engineering (HPCSE19), Soláň, Czech Republic, May 20-23, 2019.
  - 2019 • **Invited Talk:** “Iterative Linear Algebra in the Exascale Era”, Numerical Algorithms for High-Performance Computational Science, The Royal Society, London, UK, April 8-9, 2019.
  - 2019 • “The  $s$ -step Conjugate Gradient Method in Finite Precision”, SIAM Computational Science and Engineering (CSE19), Spokane, Washington, February 25 - March 1, 2019.
  - 2019 • **Invited Lectures:** “High Performance Variants of Krylov Subspace Methods, Parts I and II”, Seminar on Numerical Analysis and Winter School, Ostrava, Czech Republic, January 21-25, 2019.
  - 2018 • “Exploiting Multiprecision Hardware in Solving Linear Systems and Least Squares Problems”, Current Problems in Numerical Analysis Seminar, Institute of Mathematics, Czech Academy of Sciences, Prague, Czech Republic, December 14, 2018.
  - 2018 • “Sparse Matrix Computations in the Exascale Era”, Seminar of Numerical Mathematics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic, November 15, 2018.
  - 2018 • “Error Bounds for Iterative Refinement in Three Precisions”, SIAM Annual Meeting (AN18), Portland, Oregon, July 13, 2018.
  - 2018 • “High Performance Variants of Krylov Subspace Methods”, SIAM Parallel Processing (PP18), Tokyo, Japan, March 8, 2018.
  - 2017 • “Preconditioned GMRES-based Iterative Refinement for the Solution of Sparse, Ill-Conditioned Linear Systems”, International Conference on Preconditioning Techniques for Scientific and Industrial Applications (Preconditioning 17), Vancouver, Canada, August 2, 2017.

- 2017 ● **Invited Seminar Talk:** “Communication-Avoiding Algorithms: Challenges and New Results”, Numerical Analysis and Scientific Computing Seminar, University of Manchester, UK, July 19, 2017.
- 2017 ● “Communication-Avoiding Algorithms: Challenges and New Results”, SIAM Annual Meeting (AN17), Pittsburgh, Pennsylvania, July 13, 2017.
- 2017 ● **Invited Plenary Lecture:** “The Behavior of Synchronization-Reducing Variants of the Conjugate Gradient Method in Finite Precision”, Householder Symposium XX, Blacksburg, Virginia, June 19, 2017.
- 2017 ● **Invited Plenary Lecture:** “High-Performance Krylov Subspace Method Variants and their Behavior in Finite Precision”, High Performance Computing in Science and Engineering (HPCSE17), Soláň, Czech Republic, May 24, 2017.
- 2017 ● **Invited Seminar Talk:** “High-Performance Krylov Subspace Method Variants and their Behavior in Finite Precision”, MORE Seminar, Charles University, Prague, Czech Republic, May 15, 2017.
- 2016 ● **Invited Seminar Talk:** “Performance and Stability Tradeoffs in Large-Scale Krylov Subspace Methods”, Applied Mathematics and Scientific Computing Seminar, Temple University, November 16, 2016.
- 2016 ● “Communication-Avoiding Krylov Subspace Methods in Theory and Practice”, SIAM Conference on Parallel Processing, Paris, France, April 12-15, 2016.
- 2015 ● “The s-Step Lanczos Method and its Behavior in Finite Precision”, SIAM Conference on Applied Linear Algebra, Atlanta, Georgia, October 26-30, 2015.
- 2015 ● “Communication-Avoiding Krylov Methods in Theory and Practice”, DMML Workshop, Berkeley, CA, October 23-24, 2015.
- 2015 ● “Efficient Deflation-Based Preconditioning for the Communication-Avoiding Conjugate Gradient Method”, SIAM Conference on Computational Science and Engineering, Salt Lake City, Utah, March 14-18, 2015.
- 2014 ● **Invited Seminar Talk:** “Communication-Avoiding Krylov Subspace Methods in Finite Precision”, Linear Algebra and Optimization Seminar, ICME, Stanford University, December 4, 2014.
- 2014 ● “Avoiding Communication in Bottom Solvers for Geometric Multigrid Methods”, 8th International Workshop on Parallel Matrix Algorithms and Applications, Lugano, Switzerland, July 2-4, 2014.
- 2014 ● “Improving the Maximum Attainable Accuracy of Communication-Avoiding Krylov Subspace Methods”, Householder Symposium XIX, Spa, Belgium, June 8-13, 2014.
- 2014 ● “Avoiding Synchronization in Geometric Multigrid”, SIAM Conference on Parallel Processing for Scientific Computing, Portland, Oregon, February 18-21, 2014.
- 2013 ● “Efficient Deflation for Communication-Avoiding Krylov Methods”, Numerical Analysis and Scientific Computation with Applications, Calais, France, June 24-26, 2013.
- 2012 ● “Improving the Stability of Communication-Avoiding Krylov Subspace Methods”, SIAM Conference on Applied Linear Algebra, Valencia, Spain, June 18-22, 2012.
- 2012 ● “Exploiting Low-Rank Structure in Computing Matrix Powers with Applications to Preconditioning”, SIAM Conference on Parallel Processing for Scientific Computing, Savannah, Georgia, February 15-17, 2012.
- 2012 ● “A Residual Replacement Strategy for Improving the Maximum Attainable Accuracy of Communication-Avoiding Krylov Subspace Methods”, 9th International Workshop on Accurate Solution of Eigenvalue Problems, Napa Valley, CA, June 4-7, 2012.

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## Honors and Awards

- 2017 ● **Finalist, Householder Prize**, July 2017.

- 2013 ● Rising Stars in EECS, *Selected Participant*, MIT, November 2013.
- 2010-2013 ■ National Defense Science and Engineering Graduate Fellowship.
- 2009 ● CRA Outstanding Undergraduate Research Award, Runner-up.
- 2008 ● Microsoft Technical Scholarship Award.
- 2007 ● Lockheed Martin Distinguished Scholar Award.
- 2007 ● Computing and Communications Scholarship for Undergraduate Women, University of Virginia.

## Professional Activities

- 2023 ● Organizing Committee Member, *SIAM Conference on Computational Science and Engineering (CSE) 2023*, February 26 - March 3, 2023.
- 2021-2023 ■ Access Committee Member, *Partnership for Advanced Computing in Europe (PRACE)*.
- 2022 ● Program Committee Member, *IEEE International Parallel and Distributed Processing Symposium (IPDPS) 2022*, May 30 - June 3, 2022, Track: “Algorithms”.
- 2022 ● Program Committee Member, *Principles and Practice of Parallel Programming (PPoPP) 2022*, February 16-22, 2022.
- 2021 ● Program Committee Member, *IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '21)*, St. Louis, USA, November 14-19, 2021, Track: “Technical Papers - Algorithms”.
- 2021 ● Program Committee Member, *IEEE International Symposium on Computer Architecture and High Performance Computing (SBAC-PAD '21)*, Belo Horizonte, Brazil, October 26-29, 2021, Track: “Parallel Applications and Algorithms”.
- 2021 ● Minisymposium Co-organizer (with H. Anzt and U. Meier Yang), “Multiprecision Numerics in Scientific High Performance Computing”, *Platform for Advanced Scientific Computing (PASC)*, online, July 5-9, 2021.
- 2021 ● Minisymposium Co-organizer (with K. Lund and K. Soodhalter), “Block Krylov Subspace Methods for Scientific Computing”, *SIAM Conference on Applied Linear Algebra*, online, May 17-21, 2021.
- 2021 ● Program Committee Member, *Platform for Advanced Scientific Computing (PASC) 2021*, online, July 5-9, 2021, Track: “Computer Science and Applied Mathematics”.
- 2021 ● Program Committee Member, *IEEE International Parallel and Distributed Processing Symposium (IPDPS) 2021*, online, May 17-21, 2021, Track: “Algorithms”.
- 2021 ● Program Committee Member, *Principles and Practice of Parallel Programming (PPoPP) 2021*, online, February 27 - March 3, 2021.
- 2020 ● Program Committee Local Chair, *Euro-Par 2020*, online, August 24-28, 2020, Track: “Parallel Numerical Methods and Applications”.
- 2019 ● Minisymposium Co-organizer (with J. Šístek and P. Arbenz), “Numerical Methods for Massively Parallel Computations”, *Modelling 2019*, Olomouc, Czech Republic, September 16-20, 2019.
- 2019 ● Minisymposium Co-organizer (with A. Greenbaum), “Roundoff Error in High-Performance Implementations of CG/Lanczos-type Solvers”, *SIAM Conference on Computational Science and Engineering*, Spokane, Washington, February 25 - March 1, 2019.
- 2019 ● Primary Program Committee Member, *IEEE International Parallel & Distributed Processing Symposium (IPDPS '19)*, Rio de Janeiro, Brazil, May 20-24, 2019, Track: “Algorithms”.
- 2018 ● Program Committee Member, *IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '18)*, Dallas, USA, November 11-16, 2018, Track: “Technical Papers - Algorithms”.

- 2018 **Program Committee Member**, *IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '18)*, Dallas, USA, November 11-16, 2018, Track: "Doctoral Showcase".
- 2018 **Program Committee Member**, *SIAM Workshop on Combinatorial Scientific Computing (CSC18)*, Bergen, Norway, June 6-8, 2018.
- 2018 **Minisymposium Co-organizer** (with S. Cools), "Scalable Communication-Avoiding and -Hiding Krylov Subspace Methods", *SIAM Conference on Parallel Processing for Scientific Computing*, Tokyo, Japan, March 7-10, 2018.
- 2017 **Minisymposium Organizer**, *MS76/93: "Communication-Avoiding Algorithms"*, *SIAM Annual Meeting*, Pittsburgh, USA, July 10-14, 2017.
- 2016 **Program Committee Member**, *Technical Papers - Algorithms Track, IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '16)*, Salt Lake City, USA, November 13-18, 2016.
- 2016 **Minisymposium Co-organizer** (with L. Grigori), *MS4: "Minimizing Communication in Numerical Algorithms"*, *SIAM Conference on Parallel Processing for Scientific Computing*, Paris, France, April 12-15, 2016.
- 2015 **Minisymposium Organizer**, *MS58: "Approaches to Reducing Communication in Krylov Subspace Methods"*, *SIAM Conference on Applied Linear Algebra*, Atlanta, Georgia, October 26-30, 2015.
- 2009-2015 **Feature Editor for ACM XRDS Magazine**, Association for Computing Machinery, New York, NY.  
Lead Issue Editor for Diversity in Computer Science (V.20,4), Scientific Computing (V.19,3)
- 2014 **Organizing Committee member**, *Rising Stars in EECS Workshop*, UC Berkeley.

## Teaching Experience

- 2020 **NMNV565: High Performance Computing for Computational Science**, Instructor, Charles University, Fall/Winter 2020.
- 2020 **NMNV468: Numerical Linear Algebra for Data Science and Informatics**, Instructor, Charles University, Spring/Summer 2020.
- 2019 **NMNV565: High Performance Computing for Computational Science**, Instructor, Charles University, Fall/Winter 2019.
- 2018 **DS-GA 1004: Big Data**, Instructor, New York University, Spring 2018.
- 2017 **MATH-UA 140: Linear Algebra**, Instructor, New York University, Fall 2017.
- 2017 **DS-GA 1004: Big Data**, Instructor, New York University, Spring 2017.
- 2016 **MATH-UA 120: Discrete Mathematics**, Instructor, New York University, Fall 2016.
- 2016 **DS-GA 1004: Big Data**, Instructor, New York University, Spring 2016.
- 2015 **MATH-UA 120: Discrete Mathematics**, Instructor, New York University, Fall 2015.