

# Shelby Lockhart

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## Education

Aug 2016 – May 2023 | **University of Illinois at Urbana-Champaign**, Urbana-Champaign, IL, USA

*Doctor of Philosophy (PhD) in Computer Science*

Advisor: Luke N. Olson

Thesis Title: Reducing Communication Bottlenecks in Iterative Solvers

Research Areas: Scientific Computing and High Performance Computing

Current GPA: 3.71/4.00

Aug 2012 – May 2016 | **Wake Forest University**, Winston-Salem, NC, USA

*Bachelor of Science (BS) in Mathematics*

Double majored in Computer Science

Cumulative GPA: 3.72 / 4.00, Magna Cum Laude

## Research Experience

**Scientific Computing Group, Dept. of CS**, University of Illinois at Urbana-Champaign

*Graduate Research Assistant*

Jan 2021 - Current | Advisor: Luke N. Olson

Project: PSAAP Grant - Center for Exascale-enabled Scramjet Design

- Designed models for communication on heterogeneous architectures culminating in a publication.
- Designing optimal point-to-point communication for the unstructured-mesh boundary exchanges on heterogeneous architectures for use within the *MIRGE-Com* framework.

Aug 2017 - May 2020 | Advisor: Luke N. Olson

Project: ExxonMobil Research Grant

- Performed a performance analysis of Enlarged Krylov methods at scale.
- Developed optimal node-aware communication and implemented within the RAPtor solver framework culminating in a publication.

**Scientific Computing Group, Computation, CASC**, Lawrence Livermore National Laboratory

*Predictive Science Academic Alliance Program III Student Intern*

May 2021 - Aug 2021 | Advisor: Carol S. Woodward    Co-Advisor: David J. Gardner

- Implemented low synchronization orthogonalization methods within the SUNDIALS codebase for use within Anderson Acceleration.
- Analyzed the parallel performance of low synchronization orthogonalization methods outside of and within the context of Anderson Acceleration, culminating in a publication.

**Scientific Computing Group, Computation, CASC**, Lawrence Livermore National Laboratory

*Computation Scholar Program Graduate Intern*

Jun 2020 - Aug 2020 | Advisor: Carol S. Woodward    Co-Advisor: David J. Gardner

- Researched low synchronization orthogonalization methods and their potential use within Anderson Acceleration.

Jun 2018 - Aug 2018 | Advisor: Carol S. Woodward    Co-Advisor: David J. Gardner

- Implemented an OpenMP 4.5 N\_Vector within the SUNDIALS codebase for offloading computation to GPUs.

## **Computational and Applied Mathematics Group**, Oak Ridge National Laboratory

*Department of Energy HERE Graduate Intern*

Jun 2017 - Aug 2017 | Advisor: Clayton Webster  
Project: Study Reduced Order Modeling for Finite Element Methods

## **Scientific Computing Group, Dept. of CS**, University of Illinois at Urbana-Champaign

*Independent Study Research*

Aug 2016 - May 2017 | Advisor: Michael Heath  
Project: Analysis of the Universal Number Format

## **Dept. of Mathematics**, Wake Forest University

*Undergraduate Thesis Research*

Aug 2015 - May 2016 | Advisor: Jennifer Erway  
Project: Limited-Memory Trust-Region Methods for Sparse Relaxation

## **Cyber and Information Security Research Group**, Oak Ridge National Laboratory

*Department of Energy SULI Intern*

Jun 2015 - Aug 2015 | Advisor: Robert Bridges  
Project: STUCCO (Situation and Threat Understanding by Correlating Contextual Observations)

## **Teaching Experience**

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### **Dept. of CS at University of Illinois at Urbana-Champaign**, Urbana-Champaign, IL, USA

*Graduate Teaching Assistant*

Aug 2020 - Dec 2020 | Course: Numerical Analysis, CS 450    Supervising Professor: Luke N. Olson  
Jan 2019 - May 2019 | Course: Numerical Methods for Partial Differential Equations, CS 555  
Supervising Professor: Paul Fischer  
Jan 2017 - May 2017 | Course: Numerical Analysis, CS 450    Supervising Professor: Paul Fischer  
Aug 2016 - Dec 2016 | Course: Numerical Methods, CS 357    Supervising Professor: Andreas Kloeckner

### **Dept. of CS at Wake Forest University**, Winston-Salem, NC, USA

*Teaching Assistant*

Aug 2015 - May 2016 | Course: Computer Organization (using MIPS assembly)    Supervising Professor: Pete Santago  
Jan 2015 - May 2015 | Course: Introduction to Computer Science (using Python)    Supervising Professor: Pete Santago

## **Awards and Achievements**

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Mar 2023 | **Selected to attend Rising Stars in Computational and Data Sciences**  
Oct 2022 | **ACM/IEEE CS George Michael Memorial HPC Fellowship**, *Honorable Mention*  
Aug 2018 | **Lawrence Livermore National Laboratory**  
*Awarded Outstanding Poster Presentation*, Summer Student Poster Symposium  
Aug 2016 | **University of Illinois at Urbana-Champaign**  
*Awarded Saburo Muroga Endowed Fellowship*  
May 2016 | **Wake Forest University**  
*Awarded John W. Sawyer Prize in Computer Science*  
Apr 2015 | **Wake Forest University**  
*Inducted into Upsilon Pi Epsilon: International Honor Society for the Computing and Information Disciplines*

## Publications

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| 2023 | 1. | <b>Lockhart, S.</b> , Bienz, A., Gropp, W. & Olson, L. Characterizing the Performance of Node-Aware Strategies for Irregular Point-to-Point Communication on Heterogeneous Architectures. <i>Parallel Computing</i> (Apr. 2023).  |
|      | 2. | <b>Lockhart, S.</b> , Bienz, A., Gropp, W. & Olson, L. Performance Analysis and Optimal Node-Aware Communication for Enlarged Conjugate Gradient Methods. <i>ACM Trans. Parallel Comput.</i> <b>10</b> (Mar. 2023).   |
| 2022 | 3. | <b>Lockhart, S.</b> , Gardner, D. J., Woodward, C. S., Thomas, S. & Olson, L. N. <i>Performance of Low Synchronization Orthogonalization Methods in Anderson Accelerated Fixed Point Solvers</i> in <i>Proceedings of the 2022 SIAM Conference on Parallel Processing for Scientific Computing</i> (2022), 49–59.   |
| 2021 | 4. | Bienz, A., Olson, L. N., Gropp, W. D. & <b>Lockhart, S.</b> <i>Modeling Data Movement Performance on Heterogeneous Architectures</i> in <i>2021 IEEE High Performance Extreme Computing Conference (HPEC)</i> (2021), 1–7.  |
| 2019 | 5. | Karlin, I., Park, Y., de Supinski, B. R. & et al. (including Shelby Lockhart). <i>Preparation and Optimization of a Diverse Workload for a Large-Scale Heterogeneous System</i> in <i>Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis</i> (Association for Computing Machinery, Denver, Colorado, 2019). |
| 2017 | 6. | Adhikari, L., DeGuchy, O., Erway, J. B., <b>Lockhart, S.</b> & Marcia, R. F. <i>Limited-memory trust-region methods for sparse relaxation in Wavelets and Sparsity XVII</i> (eds Lu, Y. M., Ville, D. V. D. & Papadakis, M.) <b>10394</b> (SPIE, 2017), 95–102.   |

## Presentations

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| Apr 2023 | <b>Rising Stars in Computational and Data Sciences</b> , Austin, TX, USA<br><i>Reducing Communication Costs in Scalable Iterative Solvers</i>  |
| Feb 2023 | <b>SIAM Conference on Computational Science and Engineering (CSE23)</b> , Amsterdam, Netherlands<br><i>Anderson Acceleration on Emerging Architectures</i>   |
| Oct 2022 | <b>Center for Exascale-enabled Scramjet Design PSAAP Annual Review</b> , Urbana, IL, USA<br><i>Data Movement Modeling</i>  |
| Apr 2022 | <b>17th Copper Mountain Conference on Iterative Methods</b> , Virtual<br><i>Reducing Communication Costs in ECG with Optimal Node-Aware Communication</i>  |
| Apr 2022 | <b>Center for Exascale-enabled Scramjet Design PSAAP TST Meeting</b> , Urbana, IL, USA<br><i>Data Movement Modeling</i>  |
| Feb 2022 | <b>SIAM Conference on Parallel Processing for Scientific Computing Conference Proceedings</b> , Virtual<br><i>Performance of Low Synchronization Orthogonalization Methods in Anderson Accelerated Fixed Point Solvers</i> |
| May 2021 | <b>ASC PI Meeting 2021</b> , Virtual<br><i>Modeling Data Movement on Heterogeneous Architectures</i>   |
| Feb 2020 | <b>SIAM Conference on Parallel Processing for Scientific Computing Poster Session</b> , Seattle, WA, USA<br><i>Multi-Step Communication in Enlarged Krylov Subspace Solvers</i>  |
| Apr 2019 | <b>9th JLESC Workshop</b> , Knoxville, TN, USA<br><i>Designing Scalable Solvers for Enlarged Krylov Subspace Methods</i>   |
| Aug 2018 | <b>LLNL Summer Student Poster Symposium</b> , Livermore, CA, USA<br><i>Increasing the Portability of SUNDIALS with OpenMP 4.5</i>  |

## Codebase Contributions

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<b>RAPtor: parallel algebraic multigrid solver</b>	Contributed the implementation of block vector operations, <i>enlarged</i> Krylov methods, and <i>Split</i> optimal node-aware communication.
<b>SUNDIALS</b>	Contributed the implementation of an OpenMP 4.5 N_Vector for increased portability of the SUNDIALS software stack, as well as, low synchronization orthogonalization routines for use within Anderson acceleration in the KINSOL package.

## Relevant Skills

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<b>Programming Languages</b>	C, C++, Python, MATLAB
<b>Parallel and Distributed Computing</b>	<ul style="list-style-type: none"><li>• Extensive experience with MPI, CUDA, OpenMP (including OpenMP with device-offloading), and mpi4py</li><li>• Familiarity with PyOpenCL and PyCuda</li><li>• Experience with Make and CMake</li><li>• Extensive experience developing portable software on various large-scale HPC platforms</li><li>• Extensive experience benchmarking and modeling MPI communication performance on large-scale HPC platforms</li><li>• Experience with git for project management, as well as GoogleTest for testing</li></ul>

## Other Work Experience

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Aug 2014 - May 2016	<b>Dept. of Mathematics at Wake Forest University</b> , Winston-Salem, NC, USA <i>Math Center Tutor</i> Tutored in 9 undergraduate mathematics courses Supervising Professor: Jules Connolly
Aug 2012 - Dec 2014	<b>Best Choice Center</b> , Winston-Salem, NC, USA <i>Middle School Tutor</i> Tutored in an after-school program for low-income families Supervisor: Mildred Houser

## Service

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2022 - 2023	<b>Community Outreach</b> , Participated in discussion panels at elementary schools in Urbana-Champaign, IL
2019 - 2020	<b>SIAM Student Chapter President</b> , University of Illinois at Urbana-Champaign, IL, USA
2017 - 2018	<b>SIAM Student Chapter Officer</b> , University of Illinois at Urbana-Champaign, IL, USA

## Memberships

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Society for Industrial and Applied Mathematics (SIAM)	Women in High Performance Computing (WHPC)
Association for Computing Machinery (ACM)	Association for Women in Mathematics (AWM)
Institute of Electrical and Electronics Engineers (IEEE)	

## Professional References

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### **Luke N. Olson**

*University of Illinois at Urbana-Champaign*

- Email: [lukeo@illinois.edu](mailto:lukeo@illinois.edu)
- Website: <https://lukeo.cs.illinois.edu>

### **Carol S. Woodward**

*Lawrence Livermore National Laboratory*

- Email: [woodward6@llnl.gov](mailto:woodward6@llnl.gov)
- Website: <https://people.llnl.gov/woodward6>

### **Amanda Bienz**

*University of New Mexico*

- Email: [bienz@unm.edu](mailto:bienz@unm.edu)
- Website: <https://www.amandabienz.com>

### **William D. Gropp**

*University of Illinois at Urbana-Champaign*

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- Website: <https://wgropp.cs.illinois.edu/>