Yang Liu

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Research Interests	 Computational Electromagnetics: Fast integral and differential equation solvers for large-scale electromagnetic problems, multi-resolution algorithms for transient scattering, multi-physics and multi-scale modeling, inverse scattering. Scientific Computing: Direct solvers and preconditioners for sparse linear systems, fast algorithms for fusion simulation, quantum chemistry, power grid optimization, inverse problems, and highly oscillatory problems, randomized matrix and tensor algebras, high-performance computing, autotuning, Bayesian optimization, fast machine-learning algorithms.
Research Experience	Career (Tenured) Research Scientist , Lawrence Berkeley National Laboratory, Feb. 2022 - Present
	 Develop autotuning techniques for exascale and SciDAC applications Develop scalable sparse linear solvers Develop efficient solvers for kinetic plasma simulations Develop new formulations and solvers for acoustic and electromagnetic problems Develop fast linear and multi-linear algorithms for quantum chemistry computation Develop randomized algorithms for challenging inverse problems Develop domain-aware deep learning algorithms
	Career-Track Research Scientist, Lawrence Berkeley National Laboratory, Aug. 2019 - Jan. 2022
	 Develop butterfly-based direct solvers for sparse linear systems Develop autotuning techniques for exascale applications Develop GPU-accelerated exascale sparse linear solvers Develop efficient direct solver-based RF cavity modeling tools
	Postdoctoral Research Fellow , Lawrence Berkeley National Laboratory, Aug. 2017 - Jul. 2019
	Develop low-rank and butterfly-based hierarchical solvers for highly oscillatory problems.Develop scalable triangular solution algorithms for sparse direct solvers.
	Postdoctoral Research Fellow, University of Michigan, June 2015 - July 2017
	• Develop randomized algorithms for butterfly factorizations and butterfly-based fast direct integral equation solvers for high-frequency Helmholtz problems.
	Research Assistant, University of Michigan, Sept. 2010 - May 2015
	• Develop provably scalable and wavelet-enhanced plane-wave-time-domain algorithms for integral equation analysis of large-scale transient problems.
TEACHING	Lecturer, ACES 2024 Conference, May 2024
Experience	• Short course: Direct solvers for sparse and dense systems in electromagnetics and multi- physics simulations.
	Lecturer, IEEE NEMO Conference, June 2023

•	Short course:	Rank-structured	fast	direct	solvers	for	electromagnetics	and	multiphysics	\$
	simulations.									

Lecturer, Exascale Computing Project Annual Meeting, May. 2023

- Tutorial: SuperLU and STRUMPACK: GPU accelerated sparse factorization solvers
- Tutorial: Autotuning ECP Codes Using the GPTune Package

Lecturer, Exascale Computing Project Annual Meeting, May. 2022

- Tutorial: GPU Capable Sparse Direct Solvers
- Tutorial: Performance Autotuning of ECP Applications with Gaussian Process-Based and Cloud Database-Enhanced GPTune Package

Lecturer, Exascale Computing Project Annual Meeting, Apr. 2021

• Tutorial: GPTune: Performance Autotuner for ECP Applications

Lecturer, Exascale Computing Project Annual Meeting, Feb. 2020

• Tutorial: STRUMPACK / SuperLU: fast parallel direct linear solvers and preconditioners

Lecturer, Super Computing, Nov. 2019

• Tutorial: fast parallel direct linear solvers and preconditioners

Lecturer, IEEE NEMO Conference, May 2019

• Short course: Scalable direct solvers for electromagnetics and multiphysics simulations.

Teaching Assistant, Shanghai Jiao Tong University, Mar. 2009 - June 2009

- Instruct students in FPGA programming for digital circuit designs.
- Ph.D., Electrical Engineering, University of Michigan, May 2015 Advisor: Eric Michielssen
 - M.S., Mathematics, University of Michigan, Nov. 2014
 - B.S., Electrical Engineering, Shanghai Jiao Tong University, June 2010

HONORS AND • AWARDS •

- DOD SBIR Award (Co-PI), 2023
- LBNL Laboratory Directed Research and Development (LDRD) Award (PI), 2022
- Young Scientists Award, 3rd URSI Atlantic Radio Science Meeting (AT-AP-RASC), 2022
- Sergei A. Schelkunoff Transactions Prize Paper Award, IEEE Antennas and Propagation Society, 2018
- 1st Place in Student Paper Competition, 12th International Workshop on Finite Elements for Microwave Engineering, 2014
- 2nd Place in Student Paper Competition, 28th Annual Review of Progress in Applied Computational Electromagnetics, 2012
- Rackham Travel Grant, University of Michigan, 2012 to 2014
- Outstanding Graduate Award, Shanghai Jiao Tong University, 2010
- Third Prize in National Electronic Contest, China, 2009

SOFTWARE DEVELOPMENT

- ButterflyPACK, https://github.com/liuyangzhuan/ButterflyPACK
- GPTune, https://github.com/gptune/GPTune
- Superlu_DIST, https://github.com/xiaoyeli/superlu_dist
- STRUMPACK, https://github.com/pghysels/STRUMPACK

Reviewer	Proposals				
Experience	 DOE SBIR/STTR proposals 				

- Dutch Research Council (NWO) proposals
- Israel Science Foundation (ISF) proposals

Conference Proceedings

- PC member for International Parallel and Distributed Processing Symposium (IPDPS) 2023, 2024
- PC member for IEEE Cluster 2021
- PC member for International Conference on Parallel Processing (ICPP) 2021, 2023
- PC member for Supercomputing (SC) 2021, 2022
- IEEE AP-S/URSI Symposium 2021, 2022, 2023
- PC member for SIAM Conference on Parallel Processing for Scientific Computing (PP), 2022, 2023

Journals

- Communications in Computational Physics
- CCF Transactions on High Performance Computing
- CSIAM Transactions on Applied Mathematics
- Journal of Computational Physics
- ACM Transactions on Mathematical Software
- Applied and Computational Harmonic Analysis
- The Journal of the Acoustical Society of America
- SIAM Journal of Scientific Computing
- SIAM Journal on Matrix Analysis and Applications
- Mathematical Reviews of AMS
- IEEE Transaction on Antennas and Propagation
- IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control
- IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems
- IEEE Antennas and Propagation Magazine
- IEEE Transaction on Microwave Theory and Techniques
- IEEE Transactions on Parallel and Distributed Systems
- IEEE Antennas and Wireless Propagation Letters
- IEEE Journal on Multiscale and Multiphysics Computational Techniques
- International Journal of Numerical Modelling: Electronic Networks, Devices and Fields
- Concurrency and Computation: Practice and Experience
- Journal of Applied Computational Electromagnetics Society
- International Journal of Antennas and Propagation
- The Open Electrical and Electronic Engineering Journal
- Journal of Microwaves, Optoelectronics and Electromagnetic Applications
- Mathematics of MDPI

SESSION Organizer

- Publication chair for IEEE NEMO Conference, 2023
- Committee Member for "DOE SciDAC FASTMath Seminar Series", 2021, 2022
- Chair for "Low-Rank Compression-Based Fast Sparse Direct Solvers," SIAM Conference on Parallel Processing for Scientific Computing, 2020
- Chair for "Fast and Accurate Integral Methods for Highly Oscillatory Phenomena," SIAM Conference on Computational Science and Engineering, 2019
- Chair for "Time-Domain Computational Methods for Complex Electromagnetic and Multiphysics Problems," IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, 2019
- Chair for "Parallel Sparse Triangular Solve on Emerging Platforms," SIAM Conference on Applied Linear Algebra, 2018
- Chair for "Acceleration Techniques for Integral Equations," IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting, 2017.
- Chair for "Time-Domain Numerical Methods," IEEE International Symposium on Anten-

nas and Propagation and USNC-URSI Radio Science Meeting, 2012

- Judge for the 10th Annual Engineering Graduate Symposium, University of Michigan, 2015
- Steering Committee for "Celebrating Maxwell's Equations: 150 Years" workshop, 2015.
- Chapter Treasurer for IEEE Southeastern Michigan Section, Chapter IV, 2011-2016.
- Secretary for Technical Activities Committee, IEEE Southeastern Michigan Section, 2015-2016.
- [1] **Y. Liu**, and E. Michielssen "Parallel fast time-domain integral-equation methods for transient electromagnetic analysis," in Parallel algorithms in computational science and engineering. Birkhauser, 2020.
 - [1] Y. Liu, T. Luo, A. Rani, H. Luo, and X. Li, "Detecting resonance of radio-frequency cavities using fast direct integral equation solvers and augmented Bayesian optimization," *IEEE J. Multiscale Multiphysics Comput. Tech.*, 2023. doi:10.1109/JMMCT.2023.3311322.
 - [2] L. Claus, P. Ghysels, Y. Liu, T. Nhan, R. Thirumalaisamy, A. P. S. Bhalla, and X. Li, "Sparse approximate multifrontal factorization with composite compression methods," *ACM Trans. Math. Softw.*, 2023. doi:10.1145/3611662.
 - [3] X. Li, Y. Liu, P. Lin, and P. Sao, "Newly released capabilities in distributed-memory SuperLU sparse direct solver," *ACM Trans. Math. Softw.*, 2023. doi:10.1145/3577197.
 - [4] H. Luo, Y. Cho, J. W. Demmel, X. S. Li, and **Y. Liu**, "Hybrid models for mixed variables in Bayesian optimization," *Journal of Machine Learning Research*, (arXiv:2206.01409).
 - [5] W. Sheng, A. C. Yucel, Y. Liu, H. Guo, and E. Michielssen, "A domain decomposition based surface integral equation simulator for characterizing EM wave propagation in mine environments," *IEEE Trans. Antennas Propag.*, 2023. doi:10.1109/TAP.2023.3256579.
 - [6] Y. Liu, J. Song, R. Burridge, and J. Qian, "A fast butterfly-compressed Hadamard-Babich integrator for high-frequency inhomogenous Helmholtz equations in variable media," *SIAM J. Multiscale Model Simul.*, 2023. doi:10.1137/21M1450422.
 - [7] M. Wang, Y. Liu, P. Ghysels, and A. C. Yucel, "VoxImp: impedance extraction simulator for voxelized structures," *IEEE Trans. Comput.-Aided Des. Integr. Circuits Syst.*, 2022. doi:10.1109/TCAD.2022.3218768.
 - [8] S. B. Sayed, Y. Liu, L. J. Gomez, and A. C. Yucel, "A butterfly-accelerated volume integral equation solver for broad permittivity and large-scale electromagnetic analysis," *IEEE Trans. Antennas Propag.*, 2021. doi:10.1109/TAP.2021.3137193.
 - [9] H. Luo, J. W. Demmel, Y. Cho, X. S. Li, and **Y. Liu**, "Non-smooth Bayesian optimization in tuning problems," *Journal of Machine Learning Research*, (arXiv:2111.01730).
 - [10] Y. Liu, P. Ghysels, L. Claus, and X. Sherry Li, "Sparse approximate multifrontal factorization with butterfly compression for high frequency wave equations," *SIAM J. Sci. Comput.*, 2021. doi:10.1137/20M1349667.
 - [11] Y. Liu, Xin Xing, H. Guo, E. Michielssen, P. Ghysels, and X. Sherry Li "Butterfly factorization via randomized matrix-vector multiplications," *SIAM J. Sci. Comput.*, 2021. doi:10.1137/20M1315853.
 - [12] Y. Liu, W. Sid-Lakhdar, E. Rebrova, P. Ghysels, and X. Sherry Li, "A parallel hierarchical blocked adaptive cross approximation algorithm," *Int. Journal of High Performance Computing Applications* 2020. doi:10.1177/1094342020918305
 - [13] **Y. Liu**, and H. Yang, "A hierarchical butterfly LU preconditioner for two-dimensional electromagnetic scattering problems involving open surfaces," *J. Comput. Phys.* 2019.

BOOK CHAPTERS

REFEREED JOURNAL PUBLICATIONS

doi:10.1016/j.jcp.2019.109014

- [14] H. Guo, Y. Liu, J. Hu, and E. Michielssen, "A butterfly-based direct solver using hierarchical LU factorization for PMCHWT equations," *Microw. Opt. Technol. Lett.*, 2018. doi:10.1002/mop.31166
- [15] Y. Liu, A. C. Yucel, H. Bagci, A. C. Gilbert, and E. Michielssen, "Wavelet-enhanced plane-wave time-domain algorithm for analysis of transient scattering from electrically large conducting objects," *IEEE Trans. Antennas Propag.*, 2017. doi:10.1109/TAP.2018.28095.
- [16] A. C. Yucel, W. Sheng, C. Zhou, Y. Liu, H. Bagci, and E. Michielssen, "An FMM-FFT accelerated SIE simulator for analyzing EM wave propagation in mine environments loaded with conductors," *IEEE J. Multiscale and Multiphys. Comput. Techn.*, 2017. doi:10.1109/JMMCT.2018.2802420.
- [17] Y. Liu, H. Guo, and E. Michielssen, "A HSS matrix-inspired butterfly-based direct solver for analyzing scattering from two-dimensional objects," *IEEE Antennas Wireless Propag. Lett.* 2017. doi:10.1109/LAWP.2016.2626786
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- [19] Y. Liu, A. Al-Jarro, H. Bagci, and E. Michielssen, "Parallel PWTD-accelerated explicit solution of the time domain electric field volume integral equation," *IEEE Trans. Antennas Propag.*, 2016. doi:10.1109/TAP.2016.2546964
- [20] Y. Liu, A. C. Yucel, H. Bagci, and E. Michielssen, "A scalable parallel PWTD-accelerated surface integral equation solver for analysis of transient scattering from large-scale objects," *IEEE Trans. Antennas Propag.*, 2016. doi:10.1109/TAP.2015.2508483
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CONFERENCE PAPERS

- [1] **Y. Liu**, N. Ding, P. Sao, S. Williams, and X. S. Li, "Unified communication optimization strategies for sparse triangular solver on CPU and GPU clusters," in *The International Conference for High Performance Computing, Networking, Storage, and Analysis*, 2023.
 - [2] Y. Cho, J. W. Demmel, J. King, X. S. Li, Y. Liu, and H. Luo, "Harnessing the crowd for autotuning high-performance computing applications," in *IEEE International Parallel* and Distributed Processing Symposium, 2023. doi:10.1109/IPDPS54959.2023.00069
 - [3] Y. Liu, "A comparative study of butterfly-enhanced direct integral and differential equation solvers for high-frequency electromagnetic analysis involving inhomogeneous dielectrics," in 3rd URSI Atlantic Radio Science Meeting (AT-AP-RASC), 2022. doi:10.23919/AT-AP-RASC54737.2022.9814197
 - [4] X. Zhu, Y. Liu, P. Ghysels, D. Bindel, and X. S. Li, "GPTuneBand: multi-task and multi-fidelity Bayesian optimization for autotuning exascale applications," in *SIAM PP*, 2022. doi:10.1137/1.9781611977141.1
 - [5] Y. Cho, J. W. Demmel, X. S. Li, Y. Liu, and H. Luo, "Enhancing autotuning capabil-

ity with a history database," in IEEE 14th International Symposium on Embedded Multicore/Many-core Systems-on-Chip (MCSoC), 2021. doi:10.1109/MCSoC51149.2021.0004

- [6] Y. Liu, W. M. Sid-Lakhdar, O. Marques, X. Zhu, C. Meng, J. W. Demmel, and X. S. Li. "GPTune: multitask learning for autotuning exascale applications," in *PPoPP21*, 2021. doi:10.1145/3437801.3441621
- [7] N. Ding, S. Williams, **Y. Liu** and X. S. Li "A message-driven, multi-GPU parallel sparse triangular solver," in *SIAM ACDA*, 2021.
- [8] G. Chavez, E. Rebrova, Y. Liu, P. Ghysels and X. S. Li "Scalable and memory-efficient kernel ridge regression," in 34th IEEE International Parallel and Distributed Processing Symposium, 2020. doi:10.1109/IPDPS47924.2020.00102
- [9] N. Ding, S. Williams, Y. Liu and X. S. Li "Leveraging one-sided communication for sparse triangular solvers," in SIAM Workshop on Combinatorial Scientific Computing, 2020. doi:10.1137/1.9781611976137.9
- [10] Y. Liu, M. Jacquelin, P. Ghysels, and X. S. Li, "Highly scalable distributed-memory sparse triangular solve algorithms," in SIAM Workshop on Combinatorial Scientific Computing, 2018. doi:10.1137/1.9781611975215.9
- [11] E. Rebrova, G. Ghavez, Y. Liu, P. Ghysels, and X. S. Li, "A study of clustering techniques and hierarchical matrix formats for kernel ridge regression," in *Proc. IEEE IPDPSW*, 2018. doi:10.1109/IPDPSW.2018.00140
- [12] Y. Liu, V. Lomakin, and E. Michielssen, "Graphics processing unit-accelerated implementation of the plane wave time domain algorithm," 28th Ann. Rev. Prog. Appl. Computat. Electromagn., 2012.
- [13] J. Liang, Y. Liu, W. Zhang, Y. Xu, X. Gan, and X. Wang, "Joint compressive sensing in wideband cognitive networks," in *IEEE WCNC*, 2010. doi:10.1109/WCNC.2010.5506392

SELECTED PRESENTATIONS

- [1] **Y. Liu**, "Babich Ansatz: a Geometrical-Optics-Like Ansatz for Green's Function of Wave Equations with Variable Coefficients", in *DOE FASTMath Seminar*, 2023.
- [2] Y. Liu, "Progress on Faster Butterfly Construction Based on Randomized Matrix-Vector Multiplication", in SIAM CSE, 2023.
- [3] **Y. Liu**, "Fast Direct Solvers for Electromagnetic, Optics, Acoustic, and Elastic Applications", in *Physics-2022*.
- [4] Y. Liu, "Butterfly Compressed Babich Integrator for Solving Helmholtz Equations in Inhomogeneous Media", in *BIRS-CMO Workshop on Outstanding Challenges in Computational Methods for Integral Equations*, 2022.
- [5] **Y. Liu**, "Fast Direct Integral and Differential Equation Solvers for Electromagnetic Applications at All Frequency Ranges", in *Howard University Seminar*, 2021.
- [6] Y. Liu, "Fast Direct Integral and Differential Equation Solvers for Electromagnetic, Acoustic, and Elastic Applications at All Frequency Ranges", in *Michigan MICDE Seminar*, 2021.
- [7] Y. Liu, "Fast Direct Integral and Differential Equation Solvers for Electromagnetic, Acoustic, and Elastic Applications at All Frequency Ranges", in *Flatiron Seminar*, 2021.
- [8] Y. Liu, "Autotuning HPC and ML Applications Using GPTune ", in *Google Research Seminar*, 2021.
- [9] Y. Liu, P. Ghysels, and X. S. Li, "Butterfly-based Hierarchically Semi-separable Matrix

for Integral Equation Solvers", in URSI GASS, 2021.

- [10] Y. Liu, X. Xing, L. Claus, P. Ghysels, and X. S. Li, "Optimal-Complexity Butterfly Algorithm Based on Randomized Matvec", in *SIAM CSE*, 2021.
- [11] Y. Liu, T. Luo, and S. Tan, "A Fast Direct IE Solver for Characterization of Accelerator Cavities with Waveguide Ports", in *ICCEM*, 2020.
- [12] **Y. Liu**, P. Ghysels, L. Claus, and X. S. Li, "Butterfly-based Multifrontal Preconditioner for Wave Equations", in *HPC China*, 2020.
- [13] Y. Liu, X. Zhu, W. S-Lakhdar, X. S. Li, O. Marques, and J. Demmel, "Multitask Learning and Multi-Armed Bandit-Based Bayesian Optimization for HPC Applications", in *NYSDS*, 2020
- [14] Y. Liu, P. Ghysels, and X. S. Li, "Parallel butterfly-based Sherman–Morrison–Woodbury inversion," in *SIAM Conference on Parallel Processing for Scientific Computing*, 2020.
- [15] P. Ghysels, Y. Liu, and X. S. Li, "Incorporating hierarchical matrix compression and butterfly factorizations in a multifrontal LU solver," in SIAM Conference on Parallel Processing for Scientific Computing, 2020.
- [16] W. M. Sid-Lakhdar, Y. Liu, X. S. Li, O. A. Marques, and J. Demmel, "Autotuning exascale applications," in SIAM Conference on Parallel Processing for Scientific Computing, 2020.
- [17] Y. Liu, "Fast Algebras on Optimized Butterfly Structures," in *SIAM Conference on Computational Science and Engineering*, 2019.
- [18] **Y. Liu**, "A blocked adaptive cross approximation algorithm and its hierarchical generalization," in *Copper Mountain Conference On Multigrid Methods*, 2019.
- [19] Y. Liu, M. Jacquelin, and X. S. Li, "Enhancing scalability of parallel sparse triangular solve in SuperLU," in *SIAM Conference on Applied Linear Algebra*, 2018.
- [20] Y. Liu, and E. Michielssen, "Parallel butterfly-based direct solvers for highly oscillatory problems," in *SIAM Conference on Parallel Processing for Scientific Computing*, 2018.
- [21] Y. Liu, H. Guo, and E. Michielssen, "A HSS-type butterfly-based direct integral equation solver for 3D perfect electrically conducting objects," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2017.
- [22] Y. Liu, H. Guo, and E. Michielssen, "A linear-complexity randomized butterfly scheme for direct integral equation solvers," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2017.
- [23] W. Sheng, H. Guo, Y. Liu, A. C. Yucel, and E. Michielssen, "A butterfly-based domain decomposition SIE simulator for EM analysis of wireless communication systems in mine environments," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2017.
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algorithm for analyzing transient scattering from electrically very large PEC targets," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2014.

- [28] Y. Liu, A. C. Yucel, H. Bagci, and E. Michielssen, "Parallel time domain solvers for electrically large transient scattering problems," invited talk, in *Proc. EUCAP*, 2014.
- [29] A. C. Yucel, L. Gomez, Y. Liu, H. Bagci, and E. Michielssen, "A FMM-FFT accelerated hybrid volume surface integral equation solver for electromagnetic analysis of re-entry space vehicles," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2014.
- [30] H. Guo, Y. Liu, H. Jun, and E. Michielssen, "A parallel MLMDA-based direct integral equation solver," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2013.
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- [33] Y. Liu, A. Al-Jarro, H. Bagci, and E. Michielssen, "Parallel, explicit, and PWTD-enhanced time domain volume integral equation solver," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2013.
- [34] **Y. Liu**, A. C. Yucel, V. Lomakin, and E. Michielssen, "A scalable parallel implementation of the plane wave time domain algorithm on graphics processing unit-augmented clusters," in *Proc. IEEE Int. Symp. AP-S/URSI*, 2012.