Natalie N. Beams

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GitHub: nbeams | nbeams.github.io

Education

University of Illinois at Urbana-Champaign — Urbana, IL, USA

Ph.D. in Theoretical & Applied Mechanics   2017
  Thesis title: "High-order hybrid numerical methods using Green's functions and finite elements"

M.S. in Theoretical & Applied Mechanics   2014

University of Oklahoma — Norman, OK, USA
B.S. in Mechanical Engineering   2010
Summa cum Laude

Programming & Software

- Programming languages: **C/C++, Python** (numpy, scipy, pandas, matplotlib)**, Fortran** (90/95), Matlab

- Parallel implementation: **CUDA/HIP** and SYCL on GPUs, **OpenMP**, some experience with MPI

- Proficient with **git** version control, GitHub, Bitbucket; **LaTeX** and Overleaf for document preparation

- Experience with cluster computing environments (Slurm and PBS job schedulers)

- Contributor to open-source software packages:
    libCEED (https://github.com/CEED/libCEED), MFEM (https://github.com/mfem/mfem),
    MAGMA (https://bitbucket.org/icl/magma)

Experience

Innovative Computing Laboratory, University of Tennessee — Knoxville, TN
Research Assistant Professor   Feb. 2024 —
Research Scientist I, Linear Algebra group   Aug. 2019 —
- Contributed to two DOE Exascale Computing Project (ECP) efforts, with a focus on   Feb. 2024
  GPU computing and mixed-precision numerical methods
- Ported CUDA backends to HIP in libCEED; aided in maintenance, improvement, and
  expansion of multiple GPU backends
- Leading efforts to port the MAGMA library to SYCL
- Expanded interoperability between MFEM and Ginkgo libraries
    - Discussed in *Enabling Cross-Project Research to Strengthen Math Libraries for
      Scientific Simulations*, episode 95 of ECP's "Let's Talk Exascale" podcast

Rice University — Houston, TX
Postdoctoral Research Associate, Computational and Applied Mathematics   Aug. 2017—
- Designed and implemented a shared-memory parallel fast direct solver for the   Aug. 2019
  Helmholtz equation on multicore CPUs
    - Using OpenMP and the Intel MKL library, achieved ~10-15x speedup in build
      stage of solver and ~2x in solve stage vs. serial code for ~1 million unknowns

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University of Illinois at Urbana-Champaign — Urbana, IL

Graduate Research Assistant   Fall 2013—Spr 2017
                                                              (excl. Fall 2014)
Computational Science & Engineering (CSE) Fellow   Fall 2011—Spr 2013
College of Engineering Carver Fellow   Fall 2010—Spr 2011

- Developed a new hybrid finite element—integral equation solver for interface problems and embedded meshes
- Completed initial implementation of a finite-element-based particle-particle—particle-mesh method for N-body problems

University of Oklahoma — Norman, OK

Undergraduate Academic Assistant   Fall 2009—Spr 2010

- Created prototype GUI tools within an educational robotics SDE to aid novice computer programmers

Trane Residential Systems — Tyler, TX

Design Engineering Intern   June 2009—Aug. 2009

- Assisted in company switch to Computer Aided Design (CAD) of wiring harnesses
- Created six wiring diagrams and one complete harness design

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Papers

- *Three-precision algebraic multigrid on GPUs,* Y. M. Tsai, **N. Beams,** and H. Anzt, Future Generation Computer Systems 149, 2023

- *Mixed Precision Algebraic Multigrid on GPUs,* Y. M. Tsai, **N. Beams**, and H. Anzt, Parallel Processing and Applied Mathematics: 14th International Conference, PPAM 2022, Revised Selected Papers, Part I, 2023

- *libCEED: Fast algebra for high-order element-based discretizations,* J. Brown, A. Abdelfattah, V. Barra, **N. Beams,** J-S. Camier, V. Dobrev, Y. Dudouit, L. Ghaffari, T. Kolev, D. Medina, W. Pazner, T. Ratnayaka, J. Thompson, S. Tomov, Journal of Open Source Software 6(63), 2021

- *GPU algorithms for Efficient Exascale Discretizations,* A. Abdelfattah, V. Barra, **N. Beams**, *et al.,* Parallel Computing 108, 2021

- *Efficient exascale discretizations: High-order finite element methods,* T. Kolev, P. Fischer, M. Min, J. Dongarra, J. Brown, V. Dobrev, T. Warburton, S. Tomov, M. S. Shephard, A. Abdelfattah, V. Barra, **N. Beams**, *et al.*, The International Journal of High Performance Computing Applications, 2021

- *High-Order Finite Element Method using Standard and Device-Level Batch GEMM on GPUs,* **N. Beams**, A. Abdelfattah, S. Tomov, J. Dongarra, T. Kolev, Y. Dudouit, IEEE/ACM 11th Workshop on Latest Advances in Scalable Algorithms for Large-Scale Systems (ScalA), 2020

- *A parallel implementation of a high order accurate solution technique for variable coefficient Helmholtz problems,* **N. N. Beams**, A. Gillman, and R. Hewett, Computers and Mathematics with Applications 79(4), 2020

- *High-order Finite Element—Integral Equation Coupling on Embedded Meshes,* **N. N. Beams**, A. Klöckner, and L. N. Olson, J. Comp. Phys. 375, 2018

- *A Scalable Fast Method for N-body Problems Based on Exact Finite Element Basis Screen Functions,* **N. N. Beams**, L. N. Olson, and J. B. Freund, SIAM J. Sci. Comput. 38(3), 2016

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Presentations

- *Leveraging Mixed Precision to Accelerate High-Order Finite Element Methods on GPUs,* **N. Beams**, J. Brown, J. Thompson, Y. Dudouit, and W. Pazner, SIAM Conference on Parallel Processing for Scientific Computing (PP), 2022

- *MAGMA Backend and its Portability in Accelerating LibCEED using Standard and Device-Level Batched BLAS,* **N. Beams**, A. Abdelfattah, S. Tomov, J. Dongarra, SIAM Conference on Computational Science and Engineering (CSE), 2021

- *Coupling MFEM with Ginkgo for efficient preconditioning on GPUs,* **N. Beams**, T. Kolev, W. Pazner, H. Anzt, T. Grützmacher, P. Nayak, and T. Ribizel, CEED 4th Annual Meeting, 2020

- *An Efficient and High Order Accurate Solution Technique for Three Dimensional Elliptic Partial Differential Equations,* **N. N. Beams** and A. Gillman, SIAM Conference on Computational Science and Engineering (CSE), 2019

- *A Parallel Implementation of a Hierarchical Spectral Solver for Variable Coefficient Elliptic Partial Differential Equations,* **N. N. Beams**, A. Gillman, and R. Hewett, International Conference on Spectral and High Order Methods, 2018

- *A parallel implementation of a high order accurate variable coefficient Helmholtz solver,* **N. N. Beams**, A. Gillman, and R. Hewett, SIAM Conference on Applied Linear Algebra, 2018

- *Targeting Interface Problems at Scale with Coupled Elliptic Solvers,* **N. N. Beams**, A. Klöckner, and L. Olson, 6th Joint Laboratory for Extreme-Scale Computing Workshop, 2016

- *A Scalable Method for Cellular Blood Flow and Other N-body Systems,* **N. N. Beams**, L. N. Olson, and J. B. Freund, University of Illinois at Urbana-Champaign Computational Science & Engineering Annual Meeting, 2013

- *Ordered and chaotic flow of red blood cells flowing in a narrow tube,* **N. N. Beams** and J. B. Freund, 66th Annual Meeting of the American Physical Society Division of Fluid Dynamics, 2013

- *Stability of red cells flowing in narrow tubes,* **N. N. Beams** and J. B. Freund, 64th Annual Meeting of the American Physical Society Division of Fluid Dynamics, 2011

- *Program Visualization Tool for Educational Code Analysis,* **N. N. Beams**, 2010 Global Conference on Educational Robotics

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Posters

- *A parallel implementation of a high order accurate variable coefficient Helmholtz solver,* **N. N. Beams**, A. Gillman, and R. Hewett, Rice Oil & Gas HPC Conference, 2018

- *A method for N-Body problems based on exact finite element basis screen functions,* **N. N. Beams**, L. N. Olson, and J. B. Freund, SIAM Conference on Computational Science and Engineering, 2015

Awards & Honors

Best Workshops Paper Award, PPAM22 (for *Mixed Precision Algebraic Multigrid on GPUs* with Y. M. Tsai and H. Anzt)   2022

Recipient of Early Career Travel Award for SIAM Conference on Applied Linear Algebra   2018

Natalie N. Beams

Invited participant of "Integral Equation Methods, Fast Algorithms and   2017
Their Applications to Fluid Dynamics and Materials Science" International Program
*Institute for Computational and Experimental Research in Mathematics (ICERM)
and Hong Kong University of Science and Technology (HKUST)*

Named to "List of Teachers Ranked as Excellent by Their Students"   Fall 2014
TA for TAM 335, Introductory Fluid Mechanics

University of Illinois Computational Science & Engineering Fellow   2011-2013

University of Illinois Carver Fellow   2010-2011
One of four incoming graduate students chosen across the College of Engineering

Outstanding Sophomore in Mechanical Engineering   2007-2008

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Service

Reviewer for:
    SIAM Journal of Scientific Computing
    Parallel Computing
    Computing
    Computer Physics Communications

Program committee member:
    International Supercomputing (ISC) 2023 — Workshops
    51st International Conference on Parallel Processing (2022) — Algorithms
    International Supercomputing (ISC) 2022 — Workshops
    50th International Conference on Parallel Processing (2021) — Algorithms
    35th IEEE International Parallel & Distributed Processing Symposium (2021) —
        System Software

Officer for MechSE Graduate Women student organization   2012-2014