KIRAN RAVIKUMAR

Software Engineer, Scientific and Math Libraries
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CAREER OBJECTIVE

Research and study the fundamental behavior of turbulence using large scale numerical simulations

RESEARCH INTERESTS

Turbulence, Turbulent Mixing, Lagrangian Turbulence, Numerical Simulations and Methods for Fluid Dynamics, Leadership Computing at Exascale, GPU Computing, Performance Optimization

EDUCATION

Georgia Institute of Technology (GaTech), Atlanta, USA *Aug 2017 - Aug 2021*
Doctor of Philosophy (PhD), School of Aerospace Engineering
Georgia Institute of Technology (GaTech), Atlanta, USA *August 2015 - May 2018*
Master of Science (MS), School of Aerospace Engineering
Manipal Institute of Technology (MIT), Manipal, India *July 2011 - May 2015*
Bachelor of Technology (B. Tech), Department of Aeronautical Engineering

PHD THESIS

Title: **Extreme-scale computing and studies of intermittency, mixing of passive scalars and stratified flows in turbulence** **Defended**: July 30, 2021
Committee Members: Prof. P. K. Yeung (advisor), Prof. K. R. Sreenivasan, Prof. D. Ranjan, Prof. S. Menon, Prof. R. Vuduc
Courses: Viscous Fluid Flow, Turbulence, Dynamics of Turbulence, Numerical Linear Algebra, Numerical methods for PDEs, Advanced Scientific Computing

SKILLS

Expert proficiency	GPU programming, Parallel programming, MPI, OpenMP, Fortran CUDA Fortran, FFT, HIP, OpenACC, MATLAB, LaTeX, Linux, NVIDIA Profiler, ROC Profiler, GDB, CrayPAT, GIT,
Standard proficiency	C, C++, VisIt, ARM Forge, Docker containers, JIRA, CI/CD

PROJECTS AND EXPERIENCE

Software Engineer, Hewlett Packard Enterprise, Atlanta, GA **Sept 2021 - Present**
Role: Developer of Cray Scientific and Math Libraries for AMD and NVIDIA GPUs
- Performance optimization of linear algebra packages (BLAS and LAPACK) for AMD and NVIDIA GPUs
- Functional checkout of CRAY libsci_acc library, written in C/C++, for exascale architectures like Frontier
- Test CORAL2 exascale applications using libsci_acc. Optimize library for application use cases
- Implement OpenMP thread safety features and support for execution on multiple devices in the library
- Contribute to bug fixes, code review and documentation

Graduate Research Assistant, Georgia Tech, Atlanta, GA **Aug 2015 - Aug 2021**
Project: Extreme scale pseudo-spectral direct numerical simulations of turbulence using GPUs
- Developed an efficient large scale 3-D FFT algorithm using GPUs crucial to pseudo-spectral methods
- Designed an algorithm to process data on GPUs in batches while full data resides on CPU
- Used MPI, OpenMP, CUDA Fortran and optimized GPU-CPU data copies and off-node communication
- Developed multi-physics capability: track Lagrangian particles, passive and active scalars
- More than 3 times faster than previously used CPU based codes on Summit supercomputer

• Conducted scaling studies to help apply for computational time through the INCITE and XSEDE projects
• Performed isotropic turbulence simulations at world-record resolution of more than 5 trillion grid points on Summit using more than 18000 GPUs (more than 3000 nodes)

Project: Frontier Center for Accelerated Application Readiness
• Port pseudo-spectral CUDA Fortran code to target AMD GPUs on new Exascale Frontier supercomputer
• Enabled asynchronous execution of MPI, GPU-CPU copies and compute using advanced OpenMP features
• Used profiling tools like NVProf, CrayPAT and rocProf to identify bottlenecks for optimization
• Help develop dual-grid pseudo-spectral solver for high Sc scalars using GPUs
• Explore new approaches like MPI-IO to improve IO performance and perform IO directly from GPUs
• After graduating, I still contribute to the development of the OpenMP GPU DNS code to target simulations at 35 trillion grid points using Frontier supercomputer

Project: Advancing understanding of turbulence through extreme-scale computation
• Studied intermittency using simulations with high resolution and Taylor scale Reynolds numbers up to 1300
• Help develop Multiple Resolution Independent Simulation (MRIS) approach for simulations at large scale
• Improved statistical sampling and independence between data sets using the MRIS approach
• Computed moments of 3D local averages of energy dissipation to study power-law dependencies
• Developed GPU based post-processing codes for computationally challenging statistics like 3-D local averages
• Computed conditional moments of dissipation and enstrophy to understand how they scale with each other

Project: Extreme dissipation and its multifractal nature at high Reynolds numbers
• Study behavior of PDFs of energy dissipation and developed a stretched-exponential model to describe them
• Computed and studied the multifractal spectrum and its sensitivity to Reynolds number
• Studied the size of flow regions that contribute to extreme dissipation rates at different Reynolds numbers

Project: High resolution studies of intermittency in scalar dissipation rate
• Applied the MRIS approach to study passive scalars of Schmidt numbers around unity
• Studied conditional moments of energy and scalar dissipation to understand how they scale with each other
• Studied power-law behavior in the moments of 3D local averages of scalar dissipation

Research Intern, IBM Research, Yorktown, NY **Jun 2018 - Jul 2018**
Project: GPU accelerated 3-D FFTs computed efficiently from the large CPU memory using Summit
• Optimized performance of off-node MPI communication for 3-D FFTs using $>$ 3000 Summit nodes
• Developed optimized CUDA Fortran zero-copy kernels for fast strided copy between CPU and GPU
• Resulted in a paper published at Supercomputing 2019 as the best student paper finalist

PUBLICATIONS

• P. K. Yeung and K. Ravikumar. **Advancing understanding of turbulence through extreme-scale computation: Intermittency and simulations at large problem sizes**. *Phys. Rev. Fluids*, Nov 2020
• K. Ravikumar, D. Appelhans, and P. K. Yeung. **GPU Acceleration of Extreme Scale Pseudo-Spectral Simulations of Turbulence Using Asynchronism**. In *Proceedings of the International Conference for High Performance Computing, Networking, Storage and Analysis*, (SC '19), November 17-22, 2019, Denver, CO, USA. ACM, New York, NY, USA [*Presented as Best Student Paper Finalist*]
• S. Bak, C. Bertoni, S. Boehm, R. Budiardja, B. M. Chapman, J. Doerfert, M. Eisenbach, H. Finkel, O. Hernandez, J. Huber, S. Iwasaki, V. Kale, P. R. Kent, J. Kwack, M. Lin, P. Luszczek, Y. Luo, B. Pham, S. Pophale, K. Ravikumar, V. Sarkar, T. Scogland, S. Tian, and P. Yeung. **OpenMP application experiences: Porting to accelerated nodes**. *Parallel Computing*, 2022
• B. Chapman, B. Pham, C. Yang, C. Daley, C. Bertoni, D. Kulkarni, D. Oryspayev, E. D'Azevedo, J. Doerfert, K. Zhou, K. Ravikumar, M. Gordon, M. Del Ben, M. Lin, M. Alkan, M. Kruse, O. Hernandez, P. K. Yeung, P. Lin, P. Xu, S. Pophale, T. Sattasathuchana, V. Kale, W. Huhn, and Y. H. He. **Outcomes of OpenMP Hackathon: OpenMP Application Experiences with the Offloading Model (Part II)**. In S. McIntosh-Smith, B. R. de Supinski, and J. Klinkenberg, editors, *OpenMP: Enabling Massive Node-Level Parallelism*, pages 81–95, Cham, 2021. Springer International Publishing

MANUSCRIPTS IN PREPARATION

- K. Ravikumar, K. R. Sreenivasan, and P. K. Yeung. **Extreme dissipation and its multifractal nature at high Reynolds numbers**. *J. Fluid Mech.*, 2023
- **Exascale pseudo-spectral Direct Numerical Simulation of isotropic turbulence using Frontier**. *Comput. Phys. Commun.*, 2023

PRESENTATIONS

- P. K. Yeung, K. Ravikumar, S. Nichols, and R. Vaideswaran. **Turbulence at the Exascale: particle tracking and asynchronous GPU algorithm for low-diffusivity turbulent mixing.** In *APS (American Physical Society) March Meeting*, Las Vegas, NV, March 2023
- P. K. Yeung, K. Ravikumar, and S. Nichols. **Turbulence simulations on the verge of Exascale: GPU algorithms and an alternative to long simulations at high resolutions**. In *75th Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Indianapolis, IN, November 2022
- P. K. Yeung, K. Ravikumar, S. Nichols, and R. Vaideswaran. **Simulation of extreme-scale homogeneous turbulence on a new leadership Exascale GPU platform**. In *APS (American Physical Society) March Meeting*, Chicago, IL, March 2022
- P. K. Yeung, R. Uma-Vaideswaran, K. Ravikumar, S. Subramaniam, and D. Buaria. **Stokes point-particle dynamics and flow structure in stationary isotropic turbulence**. In *74th Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Phoenix, AZ, November 2021
- K. Ravikumar. **Extreme scale pseudo-spectral simulations of turbulence using GPUs**. In *Virtual Seminar at IIT Kanpur*, February 2021
- K. Ravikumar, P. K. Yeung, and K. R. Sreenivasan. **Reaching high resolution for studies of intermittency in energy and scalar dissipation rates**. In *73rd Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Virtual (Chicago Time), November 2020
- P. K. Yeung and K. Ravikumar. **Schmidt number effects in turbulence with active scalars**. In *73rd Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Virtual (Chicago Time), November 2020
- K. Ravikumar, O. Hernandez, J. Levesque, S. Nichols, and P. K. Yeung. **Achieving portability for a highly optimized GPU code for 3D Fourier Transforms at extreme problem sizes**. In *Performance, Portability and Productivity in HPC forum*, Virtual, September 2020
- K. Ravikumar, P. K. Yeung, and M. P. Clay. **Differential diffusion and spectral transfer in turbulent mixing at high Schmidt numbers**. In *72nd Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Seattle, WA, November 2019
- X. M. Zhai, P. K. Yeung, and K. Ravikumar. **Mixing in magnetohydrodynamic turbulence**. In *72nd Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Seattle, WA, Nov. 2019
- K. Ravikumar, P. K. Yeung, D. Appelhans, and O. Hernandez. **Experiences in porting a 3D FFT kernel from CUDA Fortran to OpenMP**. In *Department of Energy Performance, Portability and Productivity Annual Meeting*, Denver, CO, April 2019
- K. Ravikumar, D. Appelhans, and P. K. Yeung. **Extreme-scale computing for pseudo-spectral codes using GPUs and fine-grained asynchronism, with application to turbulence**. In *71st Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Atlanta, GA, November 2018
- P. K. Yeung, M. P. Clay, and K. Ravikumar. **Differential diffusion and active-scalar turbulence at high Schmidt numbers**. In *71st Annual Meeting of the APS (American Physical Society) Division of Fluid Dynamics*, Atlanta, GA, November 2018
- K. Ravikumar, D. Appelhans, and P. K. Yeung. **Turbulence Simulations and Fine Grained Asynchronism for Pseudo-Spectral Codes**. In 3^{rd} *OpenPOWER Academia Discussion Group Workshop*, Dallas, TX, November 2018

REFERENCES

- Prof. P.K. Yeung, School of Aerospace Engineering, Georgia Institute of Technology pk.yeung@ae.gatech.edu
- Dr. David Appelhans, Senior Developer Technology Engineer, NVIDIA dappelhans@nvidia.com
- Dr. Oscar Hernandez, Research Staff Member, Oak Ridge National Lab oscar@ornl.gov
- Dr. Stephen Nichols, Research Staff Member, Oak Ridge National Lab nicholsss@ornl.gov