Jason M Larkin, PhD, Lead Quantum Computing Lab, Carnegie Mellon University SEI

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CAREER OVERVIEW

I have 16 years experience in research and product development, working in the following domains:

- Quantum Computing and Information Science
- High Performance Computing: DARPA, CMU-SEI QHub, ACCESS-CI Network Research
- Materials Science: atomistic/molecular modeling, nanoscale transport
- Condensed Matter Physics: turbulence/fluid dynamics

EXPERIENCE

CMU AI Division Software Engineering Institute (2017 - Present) ***Senior Research Scientist***

- **PROJECTS**
  - **Quantum Advantage Evaluation Framework**
    - PI or co-PI (5.8M funding) on applications for quantum advantage in combinatorial optimization, materials science, machine learning, cryptography. Products are implementations and tools for DOD stakeholders.
    - Technical and software engineering lead of a group tasked with modeling scalable fault-tolerant architectures and doing quantum resource estimation for transformative Applications.
    - Created CMU-SEI QHub supporting 15 researchers, publications, presentations, and courses at CMU.
  - **US DOD OUSD Quantum Advantage in NISQ Era** PI
    - Tasked to identify potential DOD Applications that can achieve Quantum Advantage in 1-3 years given projections of hardware progress. Delivered a guide to research for to DOD OUSD management over the next 1-3 and 5-10 year timeframe.
    - Formed long-term partnerships with DOD stakeholders (AFRL, NRL, ARL) with distinct Applications (combinatorial optimization, materials science, machine learning). Continue ongoing relationship in the form of shared research and funding partnerships.
  - **CMU NSF Quantum Computing Leap Initiative** Co-PI
    - Forming inter-discplinary consortium at CMU of relevant academic departments (e.g. materials science, computer science, computer engineering) with private sector partners (Lockheed Martin, Bosch, IBM, Google) to create a Quantum Computing Center focused on Application-level research.
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  - **Pittsburgh Supercomputing Center NSF Novel Computing Platforms** Co-PI
    - Proposing a full-stack quantum computing simulation tool that will allow users to design scalable fault-tolerant quantum computers.
    - Working with private sector partners NVIDIA, Intel, and IBM to procure hardware. I am working to help define the specifications of these classical compute resources given the various types of simulation needed to model fault-tolreant quantum computers.
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- **Software Defined Hardware (SDH, DARPA)(John Wohlbier PI)**

  – Created the testing infrastructure for SEI via AWS, which utilized compilation and analysis tools (Intel, PyTorch, Tensorflow, ARM) to establish maximum theoretical and empirical performance for data-intensive workflows (machine learning, graph analytics, optimization) on commodity hardware (CPU, GPU, TPU) to compare against new software-defined hardware designs.
- **GraphBLAS Test Framework (Scott McMillan PI)**

  – Created a test framework for multiple implementations of GraphBLAS.org, including SEI's GraphBLAS Template Library https://github.com/cmu-sei/gbtl.
- **Data Protection in Virtual Environments,(DPRIVE, DARPA) (Drew Dolgert PI)**

  – Project to utilize Fully Homomorphic Encryption (FHE) for practical Machine Learning workflows. I worked to create the tests/benchmarks for performers to demonstrate the goals of computational performance and security. These tests inform new architectural designs by the performers.

SpiralGen, Inc. (2013 - 2017) ***Senior Research Engineer***

- **PROJECTS**

Supported work of commercial and research projects featuring the code-generation tool **Spiral**.

  - **Spiral Code Generation Toolbox for Matlab/Simulink and Advanced Driver Assistance Systems (ADAS)**

* Developed toolbox for Spiral code generation of Automotive Adaptive Cruise Control Using FMCW and MFSK Technology.

– **High-Assurance Cyber Military Systems (HACMS, DARPA)**
Automatically-optimized / formally-verified kernels for Cyber-Physical Systems using Spiral, plug-in for OSATE and the Architecture Analysis & Design Language (AADL), DARPA Demo Days ground/air vehicles, virtual/physical environments, Large/diverse collaboration team interacting with O(1000K) Lines of Code (LOC).

– **SpiralFFT for National Center for Supercomputing (NCSA) Blue Waters**

* Improved petascale performance of Hybrid MPI / OpenMP FFT and Stencils using Spiral. Applications include Pseudo Spectral Methods for modeling turbulence and the NEURON simulation environment.

– **SpiralGen DevOps and Cloud Infrastructure**:

* "Full-stack" software development environment for Spiral code generation. Provided Continuous Integration and Software Control Management for targeting many backends (e.g. Intel family, GPU, etc). Utilized early version of browser-based Integrated Development Environment (IDE) and virtualization on **Amazon Web Services** (AWS).
* Provided integration with Matlab/Simulink/Mex, Python/Cython, ROS, Webots, KeyMaeraX, Mathematica.

– **Power Efficiency Revolution for Embedded Computing Technologies (PERFECT, DARPA)**Eclipse RCP **first commerical release** of SpiralFFT.

– **Building Resource Adaptive Sotware Systems (BRASS, DARPA)**:Test harness for Spiral-generated resource adaptive FFT for Synthetic Apeture Radar.

- **FUNDING AND RESOURCE PROPOSALS**
  - **DOD 172-008 SBIR** (co-wrote Phase 1).
  - **DOE SG-13808 SBIR** (co-wrote, Phase 1 awarded, Phase 2 submitted, denied).
  - **DOD A15-102 SBIR** (PI, Phase 1 submitted).
  - **NSF NCSA Blue Waters PAID IME Submission** (Co-PI).
  - **Optimization of 3-D FFTs for Intel Xeon Phi and NVIDIA Kepler K20 GPUs using Spiral** (PI, awarded).

Carnegie Mellon University (2010-2012) ***TA-Heat Transfer: lectured on conduction, convection, radiation.***
University of Pittsburgh (2008) ***TA-Fluid Mechanics: viscous, boundary, scale similarity, dimensional analysis.***
University of Pittsburgh (2007-2009) ***Lecturer-Physics: mathematics, turbulence, statistics and nonlinearity.***
Precision Therapeutics (2006-2007) ***Intern-Technology Development: optical microscope automation design.***

EDUCATION

- Carnegie Mellon University Pittsburgh, PA PhD Mechanical Engineering, 2013 GPA: 3.9/4.0
  - Thesis: Vibrational Mode Properties of Disordered Solids from High-Performance Atomistic Simulations.
  - Nanostructure Thermal Conductivity: investigator for AFOSR on the DOD's HPCMP.
  - GULP: international collaboration with Julian Gale at the Nanochemistry Research Institute at Curtin University.
- **University of Pittsburgh** Pittsburgh, PA MS Mechanical Engineering, 2009 GPA: 3.7/4.0
  - **Thesis**: Statistics of Particle Concentrations in Free-Surface Turbulence.
  - **Statistics of Free-Surface Turbulence: international** collaboration with Alain Pumir and Mahesh M. Bandi.
- **University of Pittsburgh** Pittsburgh, PA BS Mechanical Engineering, 2007 GPA: 3.2/4.0
  - **Research**: FEM design of model arterial bifurcation.
- **Steel Center AVTS** Jefferson Hills, PA CADD Certification, 2002 GPA: 3.80/4.00

SKILLS/TOOLS

- **Publication and Public Speaking**: google scholar (journal pubs (18), book chapters (2), conference presentations (28).
- **"Full-Stack" Software Engineering (stacks)**:
  - Qiskit: Aqua, Terra, Ignis, Pulse, Metal
  - Microsoft Q
  - More limited experience with IntelQS, Cirq, Quimb, tkey, pyZX, STIM, XQSim
  - Python/C++/C (PyTorch/Tensforflow/NLTK/scipy/numpy)
  - Matlab-Simulink/C++/C/Fortran

– **Software Configuration Management**: svn, git, GitHub, Jenkins, JIRA. **Compilers**/**Compilation**: GNU, Intel, Visual Studio, Cython, Mex, make, cmake, MSBuild, Maven.

– **Cloud Computing**: Amazon Web Service (AWS), Azure, Docker, VirtualBox/VMWare, Ubuntu, Red Hat, CentOS, CoreOS, Windows (XP, 7, 8, Server). MPI / OpenMP, Vector Intrinsics (SSE/AVX/etc), CoArray Fortran

- **Hardware:** optics/lasers, DI/DO AI/AO interfaces, automation, machining, circuitry, robotics control.

PUBLICATIONS (SELECTED, 27 TOTAL)

- Evaluation of Quantum Approximation Optimization Algorithm, J Larkin, et al, Quantum Science and Technology (2022)
- ”Quantum Circuit Generation with SPIRAL”, S. Mionis, F. Franchetti, J. Larkin, IEEE High Performance Extreme Computing Conference Septemeber 2021.
- ”Quantum Circuit Optimization with SPIRAL: A First Look”, S. Mionis, F. Franchetti, J. Larkin, Supercomputing 2020.
- ”Assessment of Alternative Objective Functions for Quantum Variational Combinatorial Optimization ”, M. Jonsson, J. Larkin, G. Guerreschi, IEEE QCE Quantum Week 2020.
- Achieving the Quantum Advantage in Software, SEI Blog, (2019)
- ”Projecting Quantum Advantage versus Classical State-of-the-Art”, J. Larkin, D. Justice, IEEE HPEC 2019.
- High-Assurance SPIRAL: End-to-End Guarantees for Robot and Car Control, IEEE Control Systems, 2017.
- Thermal Conductivity Accumulation in a-Si from Dynamic Simulation, A. Benehban, JM Larkin, (in progress)
- Reduced thermal conductivity of Si/Ge random layer nanowires, N Samaraweera, JM Larkin, Journal of App. Physics (2018)
- Thermal conductivity accumulation in amorphous silica and silicon, JM Larkin, et al, Physical Review B 89 (14), 144303 (2014)
- Origins of thermal conductivity changes in strained crystals, KD Parrish, A Jain, JM Larkin, WA Saidi, AJH McGaughey Physical Review B 90 (23), 235201
- Predicting alloy vibrational mode properties using lattice dynamics calculations, molecular dynamics simulations, and the virtual crystal approximation, JM Larkin, AJH McGaughey Journal of Applied Physics 114 (2), 023507
- Disruption of superlattice phonons by interfacial mixing, SC Huberman, JM Larkin, AJH McGaughey, CH Amon Physical Review B 88 (15), 155311
- Power-law distributions of particle concentration in free-surface flows, J Larkin, et al, Physical Review E 80 (6), 066301 (2009)

PRESENTATIONS (SELECTED, 28 TOTAL)

- Effect of noise models on QAOA performance for Max-Cut, R. Majumdar, J. Larkin, G. Guerreschi, S. Susmita, APS March Meeting 2021.
- Evaluation of QAOA, J. Larkin(speaker), Association Quantum, DC Quantum Meetup 2020.
- Quantum Circuit Optimization with SPIRAL, S. Mionis, J. Larkin, et al, Supercomputing 2020 (best presentation noimnee).
- Assesing Objective Functions for Quantum Variational Optimization, M. Jonsson, J. Larkin et al, IEEE Quantum Week 2020.
- Projecting NISQ-era quantum advantage with QAOA GG Guerreschi, J Larkin, et al American Physical Society 65 2020.
- SpiralFFT for Blue Waters, **J.M. Larkin (speaker)**, NCSA Symposium for Petascale 2015.
- “Predicting Vibrational Mean Free Paths in Disordered Systems”, J.M. Larkin, A.J.H. McGuaghey, presented at 2013 ASME Summer Heat Transfer Conference Minneapolis, MN.
- “Effect of Interspecies Mixing on Phonon Mean Free Paths in Superlattices”, S.C. Huberman, J.M. Larkin, A.J.H. McGaughey, C.H. Amon, presented at 2013 ASME Summer Heat Transfer Conference Minneapolis, MN.
- “Origin of Thermal Conductivity Changes in Strained Systems”, K. Parrish, J.M. Larkin, A.J.H. McGaughey, presented at 2013 ASME Summer Heat Transfer Conference Minneapolis, MN.
- Virtual Crystal Approximation, **J.M. Larkin (speaker)**, 2013 MRS Spring Meeting San Francisco, CA.
- “Ordered and Disordered Contributions to Lattice Thermal Conductivity”, J.M. Larkin (speaker), A.J.H. McGaughey, presented at 2012 PHONONS Conference Ann Arbor, MI.
- “Predicting Phonon Properties of Silicon from First-Principles Calculations”, J.M. Larkin, A.J.H. McGaughey (speaker), W.A. Al-Saidi, presented at 2012 ASME Summer Heat Transfer Conference Puerto Rico, USA.
- Generalized Fractal Dimensions...Turbulence, **J.M. Larkin (speaker)**, 2008 American Physical Society March Meeting.
- Flow Chamber to Explore the Development of Cerebral Aneurysms, J. Larkin, et al, 2007 Biomedical Engineering Society.