UKC 2023 Keynote Symposium

Computational Science and Engineering:

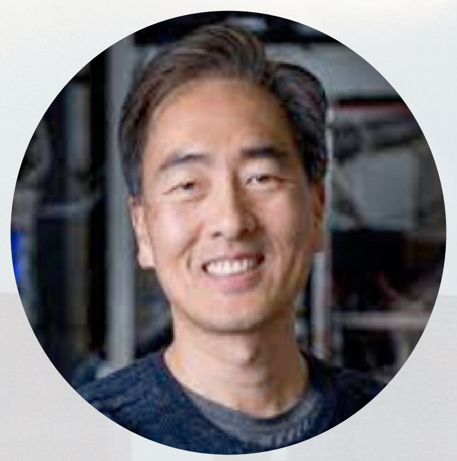
Advances in Quantum and High Performance Computing

10:30am, August 3, 2023, Thursday, Enterprise Ballroom 7-8

UKC 2023 Dallas

Discovery, Innovation and Dissemination for Transformative Impact

High performance computing is at the heart of modern technology, enabling computational sciences, artificial intelligence and information technology. Customized computational resources are deployed in hybrid high performance computing environments to support optimized execution of critical tasks. Quantum computers provide a promise for tackling challenging problems that are intractable using conventional computational capabilities. This symposium will discuss advances in high performance computing, and explore the future trends enabled by quantum computing in hybrid HPC environment.



Jungsang Kim

Chair

Schiciano Family Distinguished Professor
Electrical and Computer Engineering and Physics
Duke University
Co-Founder and CTO
IonQ

Jungsang Kim is the Schiciano Family Distinguished Professor of Electrical and Computer Engineering and Physics at Duke University, and a Co-Founder and Chief Technology Officer of IonQ, Inc. Kim has pioneered the technology development, system engineering and commercialization of quantum computers based on trapped atomic ions, by leading numerous multi-disciplinary collaborative research initiatives in the US. Prior to Duke University, Kim was a Member of Technical Staff and Technical Manager at Bell Laboratories, leading the development and commercialization of large-scale optical switches and wireless communication systems. He received his Ph.D. degree in Physics from Stanford University (1999) and BS degree in Physics from Seoul National University (1992). He is a Fellow of the American Physical Society and Optica (formerly Optical Society of America).

Christopher Monroe

Presenter

Gilhuly Family Presidential Distinguished Professor
Electrical and Computer Engineering and Physics
Duke University
Co-Founder and Chief Scientist
IonQ, Inc.

Quantum Computers: Applications and Implementations

Quantum computers exploit the bizarre features of quantum physics -uncertainty, entanglement, and measurement - to perform tasks that are impossible using conventional means, such as computing over huge amounts of information, and communicating via teleportation. I will summarize the foundations of quantum computation and the potential exponential scaling quantum computers may hold over conventional computation, along with some examples of quantum speedups based on the parallelism of quantum superposition. I will conclude with a summary of the leading quantum computer architectures, particularly those based on individual atoms, suspended and isolated with electric fields, and individually addressed with laser beams. Ion trap quantum computers have essentially perfect idle qubit/spin coherence properties with fully-connected and reconfigurable entanglement operations. I will present recent results with state-of-the-art ion trap quantum computer systems and simulators, from both the Duke Quantum Center and IonQ, Inc., and summarize the outlook for further scaling of ion trap quantum computers based on a well-defined and modular architecture.

Christopher Monroe is the Gilhuly Family Presidential Distinguished Professor of Electrical and Computer Engineering and Physics at Duke University, and the Co-Founder and Chief Scientist of IonQ, Inc. Monroe has pioneered nearly all aspects of trapped ion quantum computing and simulation, from the demonstration of the first quantum gate, a monolithic semiconductor chip ion trap, and photonic interconnections between separated ion trap systems. He is a key architect of the US National Quantum Initiative, a Fellow of the American Physical Society, Optical Society of America, the UK Institute of Physics, the American Association for the Advancement of Science, and is a member of the National Academy of Sciences.

Jaejin Lee

Presenter

Dean
Graduate School of Data Science
Professor
Dept. of Computer Science and Engineering
Seoul National University

Quantum Computing, Deep Learning, and Accelerated Computing

The deep learning language models, which have recently been in the limelight, require supercomputer-level computing resources that are made up of hundreds or thousands of GPU computer systems when training. Quantum computing is a fundamentally different computing paradigm and is seen as a future option to solve the intractable problems of classical computing using digital computers. However, current quantum computers are still noisy and error-prone, so classical simulation of quantum circuits is essential for the verification of quantum computers and the development of complex quantum algorithms. Classical simulations of large quantum systems mainly use supercomputers because they require exponential memory space and computational complexity depending on the number of qubits. Accelerated computing is a method of mixing a traditional CPU with an accelerator. It is a computing model that reduces computing time by accelerating a specific task in a special processor called an accelerator. Currently, GPUs, FPGAs, and NPUs are mainly used as accelerators. This talk examines the relationship between quantum computing, deep learning, and accelerated computing, and discusses the desirable research direction from the software point of view.

Jaejin Lee is the Dean of Graduate School of Data Science and Professor at the Dept. of Computer Science and Engineering at Seoul National University (SNU). He also serves as the Director of the Center for Optimizing Hyperscale AI Models and Platforms and the Thunder research group at SNU. He received his Ph.D. degree in Computer Science from the University of Illinois at Urbana-Champaign (UIUC) in 1999. He received an MS degree in Computer Science from Stanford University in 1995 and a BS degree in Physics from SNU in 1991. After obtaining the Ph.D. degree, he spent half a year at UIUC as a visiting lecturer and postdoctoral research associate. He was an assistant professor in the Department of Computer Science and Engineering at Michigan State University from January 2000 to August 2002 before joining SNU. He is an IEEE fellow.

Alexander (Lex) Kemper

Presenter

Associate Professor
Department of Physics
North Carolina State University

Opportunities for Quantum/Classical Computing

Quantum computing has the potential to help us overcome the barriers that are presented by the end of Moore's law. In the natural sciences, these barriers appear as limitations in computer memory and/or processing speed which prevent scientists from describing the problem fully and forcing them to work on smaller models or with approximate methods. Since nature is fundamentally quantum, it is quite natural to view a quantum computer as a bespoke quantum simulator, where we can examine the open problems in science at a scale not possible with classical computers. In this talk, I will present how this is achieved, discuss some recent advances in the area. In addition, I will discuss the limitations of quantum computing, and where classical computing can play an important role, for both today's quantum hardware and going into the fault-tolerant quantum era.

Lex Kemper is an associate professor in the Department of Physics at North Carolina State University. His work centers at the intersection of quantum computing and condensed matter physics, where his group is studying how near- and future-term quantum computers could be of use in solving outstanding problems in physics. He received his Ph.D in Physics from the University of Florida in 1999, following a BS degree in Physics and Mathematics from the same institution. After obtaining his Ph.D., he spent 2 years at Stanford as a postdoctoral research associate, and 3 years at Lawrence Berkeley National Laboratory as an Alvarez Fellow before joining NC State.

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