IEEE International Conference on Quantum Computing and Engineering — QCE24

2024 IEEE Quantum Week

IEEE International Conference on Quantum Computing and Engineering (QCE24)

Palais des Congrès Montréal, Québec, Canada (Room 520A)

Wednesday September 18th, 2024

Fifth Workshop on

Quantum Computing Opportunities in Renewable Energy and Climate Change

Organizers: Annarita Giani (GE Vernova Advanced Research), Zhenyu (Henry) Huang (Argonne National Laboratory)

Times are given in Eastern Time (ET, UTC-5:00)

10:00-10:15 Welcome Annarita Giani, Zhenyu (Henry) Huang

Session 1 (Keynotes + 1 Talk, 1.5 hours)

10:15-10:40 Keynote: **Harnessing the Power of Quantum for our Future** **Bill Foster,** U.S. Congressman **(**20+5 virtual)

Bio. Congressman Bill Foster is a scientist and businessman representing Illinois' 11th Congressional District since 2013, and previously the 14th District from 2008 to 2011. He is the only PhD physicist in Congress. He serves on the House Financial Services Committee, advocating for consumer protections and economic reforms, and is the Ranking Member of the Subcommittee on Financial Institutions and Monetary Policy. Previously, Bill served on the House Science, Space, and Technology Committee, promoting evidence-based policies, climate change initiatives, and energy innovation. He also chaired the Science Committee's Investigations and Oversight Subcommittee, overseeing federal scientific research.

Before Congress, Bill co-founded Electronic Theatre Controls, Inc. at age 19 and worked as a high-energy physicist at Fermilab, where he contributed to the discovery of the top quark and led the design of particle accelerators and detectors still in use today

10:40-11:05 Quantum Computing and Quantum Artificial Intelligence for Climate Change and Water Engineering **Kin Tung Michael Ho, Kuan-Cheng Chen, Lily Lee, Felix Burt, Shang Yu, Po-Heng Henry Lee**, Imperial College London (25+5)

Bio. Michael Ho is currently a PhD student in Environmental Engineering at Imperial College London, specializing in the modeling of micro-aerated anaerobic digestion processes. His research focuses on biological thermodynamics, quantum probability models for gene regulation, and quantum machine learning applications in water engineering. Alongside his academic work, Michael has worked as a policy-support assistant at the Imperial Centre for Quantum Engineering, Science and Technology, and is a committee member of the college's Quantum Technology Society.

Abstract. The escalating impacts of climate change and the increasing demand for sustainable water management necessitate innovative technological solutions. Quantum computing (QC) and quantum artificial intelligence (AI) emerge as promising tools with the potential to revolutionize these critical areas. This review explores the application of quantum machine learning and optimization techniques in addressing climate change and enhancing water engineering practices. Traditional computational methods often fall short in handling the scale and complexity of climate models and water resource management. Quantum advancements, however, offer significant improvements in computational efficiency and problem-solving capabilities. By synthesizing the latest research and developments, this paper highlights how QC and quantum AI can optimize renewable energy systems and water management

infrastructures. The paper also evaluates the performance of current quantum algorithms and hardware in practical applications, setting realistic expectations for their future impact on environmental sustainability. The integration of these quantum technologies promises to drive significant advancements in achieving climate resilience and sustainable water management.

11:05-11:30 Exploring Use Cases of Quantum Computing in the Alberta Energy Sector, Adam Bene Watts University of Calgary (20+5)

Bio. Dr. Bene Watts is currently a scientist in residence at Quantum City at the University of Calgary. Previously he worked as a postdoc at the Institute for Quantum Computing at the University of Waterloo. He completed my Ph.D. at MIT under the supervision of Professor Aram Harrow and an undergraduate degree in Math and Physics at McGill University.

Abstract. Quantum City is an institute within the University of Calgary formed as the result of a strategic partnership between the University, the Government of Alberta, and leading technology company Mphasis. Its mandate is to establish quantum-focused fabrication infrastructure, new talent development programs, and adoption pathways to support the development of a vibrant economic and scientific hub based in Calgary. In 2023, Quantum City launched the Quantum City Challenge – a global quantum tech competition aimed at finding quantum solutions for real-world problems faced by today's energy industry. The challenge closed in May 2024, and winners were recently announced.

In this talk I'll share some details of the problems proposed for the challenge and the winning submissions. I'll also discuss the lessons Quantum City learned while running the challenge, and how those lessons are helping inform Quantum City's strategy for use-case development. Finally, I'll cover Quantum City's current efforts concerning use-case development in the energy sector and beyond.

11:30 *Wrap up session 1* *(Annarita and Henry)*

11:30-13:00 Break

Session 2 (3 Talks, 1.5 hours)

13:00-13:30 Keynote: Current and Future Quantum Applications for Energy at DOE, Rima Oueid, U.S. Department of Energy (20+5)

Bio. Rima Oueid is a senior commercialization executive with expertise in finance, strategy, and energy policy. She works with diverse stakeholders to create business models that commercialize innovative technologies and tap into various capital sources to provide energy solutions. Currently, Rima focuses on quantum information science, AI, microgrids, and bidirectional vehicle electrification. Previously, she served in the Office of Policy and Hurricane Sandy Task Force, helping manage $15 billion in energy infrastructure projects, including the NJ TransitGrid and NJ Energy Resilience Bank. She also contributed to a 3GW power purchase agreement for the U.S. Department of Defense and led a $600 million energy finance portfolio for the Energy Efficiency and Renewable Energy Office.

Before her government roles, Rima worked in finance, real estate, and management consulting, including at Accenture, William Harris Investors, and CID Equity Partners. She holds an MBA from the University of Chicago Booth School of Business and a BS from the University of Illinois.

13:30-14:00 Quantum-Train Long Short-Term Memory: Application on Flood Prediction Problem, Chu-Hsuan Abraham Lin, Chen-Yu Liu, Kuan-Cheng Chen, Imperial College London, and National Taiwan University (25+5)

Bio. Chen-Yu Liu is currently a PhD candidate at the Institute of Applied Physics, National Taiwan University.

His research is currently focus on training classical neural network models by quantum machine learning techniques.

The topic today is a winning project at the Deloitte's Quantum Climate Challenge 2024 event, as an example of his proposed method called quantum-train.

Abstract. Flood prediction is a critical challenge in the context of climate change, with significant implications for ecosystem preservation, human safety, and infrastructure protection. In this study, we tackle this problem by applying the Quantum-Train (QT) technique to a forecasting Long Short-Term Memory (LSTM) model trained by Quantum Machine Learning (QML) with significant parameter reduction. The QT technique, originally successful in the "A Matter of Taste" challenge at QHack 2024, leverages QML to reduce the number of trainable parameters to a polylogarithmic function of the number of parameters in a classical neural network (NN). This innovative framework maps classical NN weights to a Hilbert space, altering quantum state probability distributions to adjust NN parameters. Our approach directly processes classical data without the need for quantum embedding and operates independently of quantum computing resources post-training, making it highly practical and accessible for real-world flood prediction applications. This model aims to improve the efficiency of flood forecasts, ultimately contributing to better disaster preparedness and response.

14:00-14:30 Quantum Computing for Modeling of Sustainable Materials Thomas Baker, University of Victoria(25+5)

Abstract. I review some algorithms that have application in the computation of quantum chemistry. I discuss equivalent classical algorithms and where a quantum advantage can be found.

Bio. Thomas E. Baker holds a Tier 2 Canada Research Chair in Quantum Computing for Modelling of Molecules and Materials in the Department of Physics & Astronomy and also the Department of Chemistry at the University of Victoria. He is also an affiliate member of the Centre for Advanced Materials and Related Technologies (CAMTEC) at the University of Victoria. He has a broad background in density functional theory, quantum algorithms, quantum information, and entanglement renormalization methods. He is the lead-developer of the DMRjulia entanglement renormalization library and has written introductory materials for it.

In 2021, he was a Fulbright U.S. Scholar at the University of York in the United Kingdom. From 2017-2020, Prof. Baker was the Prized Postdoctoral Scholar in Quantum Sciences and Technology at Institut quantique à l'Université de Sherbrooke.

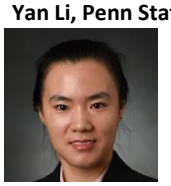
Prof. Baker is a member of the education committee for the NSERC CREATE program in Quantum Computing affiliated with Quantum BC. He is the Principal Investigator of the quantum photonics, algorithms, light-matter interactions for technology (QuALITy) collaboration at the University of Victoria. He remains committed to building a diverse research group capable of handling the multitude of challenges related to his wide research interests.

14:30-15:15 Afternoon Break

Session 3 (Panel Discussion, 1.5 hours)

15:15-16:45 ***Panel Discussion (1.5 hours)***

1. **Yan Li, Penn State University**



Bio. Yan Li received her Ph.D. degree from the University of Connecticut, Storrs, CT, U.S., in 2019. She also received a Ph.D. degree from Tianjin University, Tianjin, China, in 2013. Both are in electrical engineering. She is currently a Charles H. Fetter Endowed Fellow Assistant Professor at the School of Electrical Engineering and Computer Science at Pennsylvania State University. Her research interests include cyber-physical power systems, quantum computing, data-driven modeling and control, stability, resilience analysis, cybersecurity, etc. Dr. Li has received several prestigious awards, including the IEEE-PES Outstanding Engineer Award and the Women of Innovation Award. Her team is currently funded by the Office of Naval Research to develop quantum techniques for power systems. She also serves as an IEEE representative for the Quantum Economic Development Consortium and chairs the IEEE Power and Energy Society Quantum Task Force.

2. **Clarence Chang, Argonne National Laboratory** (Virtual)

Bio. Clarence's interests focus on observational cosmology with a particular emphasis on developing new superconducting technology for use in new experiments. He is part of a joint Chicago/Argonne superconducting detector development collaboration which is developing and building the focal plane for the upcoming SPT-3G experiment. This focal plane, with over 16,000 polarization sensitive detectors, will enable the South Pole Telescope to observe 2500 square degrees with unprecedented sensitivity. SPT-3G will explore the physics of inflation, dark energy, and the cosmic neutrino background.

3. **Juliette Peyronnet, Alice&Bob**

Bio. Juliette Peyronnet is a physicist specializing in photonics and has over seven years of extensive leadership experience in commercializing deep-tech products. Currently serving as US General Manager at Alice&Bob, she leads the engagements with end users, governmental agencies, and technological and academic partners. She used to work at Xanadu as a Business Development Lead, working with Fortune 500 companies and governments globally to secure research contracts and establish revenue strategies. Previously, at the French Trade Office Embassy in Toronto, she advised deep-tech startups on international expansion strategies, facilitating impactful industry collaborations. With a Master's degree from Institut d'Optique Graduate School and entrepreneurial training from HEC Paris, she brings a unique blend of academic rigor and strategic acumen to drive innovation in quantum technologies and beyond.

4. **Masako Yamada, Director of Application Development at IonQ**

Bio. As Director of Applications Development, Masako works with global enterprise clients who are pursuing commercial advantage through quantum computing. The IonQ Applications is a multidisciplinary team that develops novel quantum algorithms -- uniquely optimized for IonQ quantum processors -- for chemistry, optimization, AIML and physics applications. Masako was an early adopter of leadership-class HPC and hybrid CPU/GPU computing and is excited to drive growth in quantum computing as a vendor. She was previously at GE Research for 20 years developing new technologies for multiple lines of business, as well as government clients. She brings a business-aware, customer-first perspective to innovation.

5. **Peng Zhang, Stonybrook University**

Bio. Dr. Peng Zhang is a Full Professor of Electrical and Computer Engineering, and a SUNY Empire Innovation Professor at Stony Brook University, New York. His research interests include AI-enabled smart grids, quantum-engineered power grids, networked microgrids, power system stability and control, cybersecurity, and formal methods and reachability analysis. He is the author of Networked Microgrids published by Cambridge University Press, and Microgrids: Theory and Practice by Wiley-IEEE Press. Dr. Zhang established a series of quantum computing, quantum security, quantum networking and quantum machine learning algorithms that have been successfully implemented on today's noisy intermediate-scale quantum computers to solve challenging power system problems.

- Presentations – 50 mins total (10 mins each)
- Discussion/Questions from organizers - 20 mins
- Questions from audience - 20 mins

16:45-16:45 Workshop *Wrap up* Henry, Annarita