Wisconsin Quantum Institute Awarded Grant to Advance Quantum Computing Machine Learning

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Oct. 9, 2019 — The U.S. Department of Energy recently announced the funding of another set of quantum science-driven research proposals, including that of Sau Lan Wu, Enrico Fermi professor of physics and Vilas Professor at the University of Wisconsin – Madison. With the funding, Wu and her collaborators seek to tap into the power of quantum computing to analyze the wealth of data generated by high energy physics experiments.

The title of Wu's DOE approved project is: "Application of Quantum Machine Learning to High Energy Physics Analysis at LHC using IBM Quantum Computer Simulators and IBM Quantum Computer Hardware".

Wu, a member of the Chicago Quantum Exchange (CQE) and Wisconsin Quantum Institute at UW–Madison who conducts her research at the Large Hadron Collider (LHC) at CERN in Geneva, Switzerland, was one of only six university-based investigators – those outside of National Labs – to be awarded the DOE quantum funds for particle physicists.

"The ambitious HL-LHC program will require enormous computing resources in the next two decades," says Wu. "A burning question is whether quantum computers can solve the ever-growing demand for computing resources, and our goal here is to explore and to demonstrate that quantum computing can be the new paradigm."

Wu's research program has one major goal: to discover new physics. This goal requires the identification of rare signals in immense backgrounds. Wu's group has pioneered the use of machine learning algorithms on standard computers to move quickly and accurately to extract the physics signal. Sifting through the data to find meaningful and incredibly rare signals takes inordinate computing power at LHC.

"However, because of the rapidly increasing volume of data in the future HL- LHC program, our current machine learning algorithms just don't have enough computing power to conduct complex analyses," Wu says. "We believe that applying quantum machine learning methods may well be a new direction to go."

For her DOE-funded project, Wu works with collaborators in quantum information science, including Miron Livny, professor of computer sciences with the Wisconsin Institute for Discovery at UW–Madison, and OpenLab of the CERN IT division. Importantly, she is also collaborating with scientists at IBM Zürich Research. Through them she has access to their quantum computer simulators and quantum computer hardware.

With IBM's innovative quantum technologies, Wu and her team plan to overcome the challenges imposed by the large, complex datasets generated from the HL-LHC experiments. They will work on quantum feature map with entangling qubits – quantum bits used in quantum computers – to be able to encode the large datasets into the limited number of qubits. They will also work on improving quantum algorithms to advance machine learning, which they expect will lead to advances that have wide-ranging benefits outside of high energy physics.

"Although the era of efficient quantum computing may still be years away, we have made promising progress and obtained preliminary results in applying quantum machine learning to high energy physics with IBM's resources," Wu says. "The US government, as well as US industrial counterparts, are planning to invest heavily in quantum computing in order to lead the international competition in the area of quantum information science technology, and we are excited to be able to apply these technologies to discoveries in high energy physics."

Wu's DOE grant marks the second to be earned by WQI members this summer. In July, Shimon Kolowitz and collaborators were awarded a grant to identify and mitigate the sources of noise that currently limit qubit performance.