DEPARTMENT OF MATHEMATICS AND STATISTICS

WRIGHT STATE UNIVERSITY

COLLOQUIUM

SPEAKER:	**Dr. Nella Ludlow, Wright State University**
TITLE:	**Error Correction Methods for Quantum Information Systems**
DATE:	**October 20, 2023**
ROOM/TIME:	**Time 3:00 p.m. Room 271 MM**
HOST:	**Dr. Xiangqian Zhou**

ABSTRACT:

In October 2019, Google claimed breaking the "Quantum Advantage" milestone solving a specific problem in roughly 200 seconds that was estimated to take over 10,000 years on the world's largest supercomputer at the time, Oak Ridge National Lab's Summit supercomputer.

Quantum algorithms give reasonable hope to tackle some NP-class problems, which could help find new medicines, create new chemical compounds, discover new battery technology, create solutions to world climate issues, and model complex behavior from subatomic physics to meteorology.

Quantum algorithms, such as Shor's algorithm, also provide a method to break current encryption methods, causing a worldwide push to change encryption to Post-Quantum Cryptography (PQC) for banking, military and others. In 2024, NIST will publish a Federal Information Processing Standard (FIPS) for the PQC algorithms.

This talk will briefly cover quantum representation, Bloch Sphere, Quantum Gates, use of Unitary Matrices for quantum logic, use of matrix multiplication and tensors for calculating quantum states on classical computers, and Shor's and Grover's Quantum Algorithms to make the talk accessible to those not familiar with quantum information systems.

Current quantum computers are highly susceptible to noise and disturbances, causing qubits to be error prone due to energy relaxation and decoherence. This means that current quantum computers are operating in an environment known as "Noisy Intermediate-Scalable Quantum" or NISQ era. To transition to a more-useful fault-tolerant environment, researchers must find efficient Quantum Error Correction methods. This is not an easy task as quantum states cannot be measured or copied without collapsing the state via the No-Cloning Theorem.

Quantum Error Correction (QEC) is arguably the most important aspect to building tractable quantum information systems.

The presentation will look at previous motivation and methods of QEC to include: Use of classical coding theory, quantum entanglement for repetition coding, Shor's 9-bit codes, Calderbank-Steane-Shor 7-bit codes, Caldebank-Raines-Sloane and Gottesman 5-bit codes, Quantum Fault Tolerance, and Magic States.

The speaker will propose other ideas of QEC to include: Low- Density Parity Check (LDPC) Codes, Topological Codes, Parallel Approaches using Imperfect Cloning.

ABOUT THE SPEAKER:

Nella Ludlow is the Director of Quantum Computing and a Research Professor of Computer Science at Wright State University, and an Adjunct Full Professor of Mathematics at Washington State University. She has also taught at the University of Washington, the Naval Postgraduate School, and the University of Cambridge, England.

She holds a Bachelor's degree in Mathematics and Physics from Washington State University, Master's degree in Computer Science from Wright State University, a PhD in Artificial Intelligence from University of Edinburgh, Scotland, Post-Doctoral studies in Computer Science at University of Cambridge, England, and Certification in Quantum Computing from Massachusetts Institute of Technology (MIT).

She is a retired US Air Force officer having served as a Mathematician, a Pilot, an Intelligence Officer at NASIC, and was the Technical Director of Artificial Intelligence at AFRL. She holds ten patents.

She also serves on the Scientific Working Group for Artificial Intelligence for the Federal Bureau of Investigation (FBI), on Canada's equivalent to the National Science Foundation or NSF, in a group called NSERC selecting Quantum Information Science research funding for Canada, and serves on the IEEE Standards Association working group for Quantum and Cybersecurity (SC10).

She also has been CTO of a Microsoft-funded startup and CEO of two technical companies, taking one public on the New York Stock Exchange (NYSE).