Title: Metrology to Machine Learning

Speaker: Prof. Manas Mukherjee (NUS, Singapore)

Abstract: Superconducting qubits and photonic qubits are widely used to develop quantum circuits. This talk is centred around the use of atomic qubits. The speaker discusses some major applications undergoing in his lab. It includes axial nuclear moment coupling dark matter, quantum heat engine and building machine-learning classifier.

The atomic under discussion is **Ba** ion trapped by laser cooling. They have employed Doppler cooling and sideband cooling as per the demand for experimental precision. The qubit transition takes place *S* and *D* quadrupole transition of the **Ba** atom trapped by the laser. Such qubits have a decoherence time of 3 ms. Till now, they have stably trapped 30 ions together using this technique.

The first discussion on the utility of ion trapped was in quantum metrology. He discussed the limit on measurement uncertainty in terms of Quantum Fisher information (QFI). Fisher information is defined as information contained in a data set about any parameter of interest. The variance scales as the inverse of N and T squared. Where N is the number of measurements, while T is probing time. He showed that this could be improved by correlated probe measurements and if a probe has a non-linear phase dependence.

At last, he mentioned the use of ion trapped system for an efficient solution to machine learning classification problems. With technical advancements in qubit chips, the number of qubits is increasing with time. This opens new possibilities for solving machine-learning problems. The speaker mentions how feature detection by neural networks can be converted into an equivalent problem of dynamics of qubits in Hilbert space. Similar to updating the weight function in the classical neural networks, we do data re-uploading to the quantum classifier circuit. This makes it resource efficient classifier.

He also briefly mentioned the striking similarity between the hamiltonian for the axial nuclear moment coupling of dark matter and the trapped ion system under suitable conditions. This could help in an efficient and accurate simulation of dark matter systems using their setup.