Machine-learning-driven design, tuning, and characterisation of spin qubit arrays

Natalia Ares

The operation of large semiconductor quantum-dot arrays is increasingly limited by the complexity of device design, simulation, tuning, and long-term stabilisation. This talk presents machine-learning-driven frameworks that address these challenges across the spin-qubit development workflow. I will first demonstrate fully autonomous tuning of singlet–triplet and Loss–DiVincenzo qubits in the QARPET (Qubit-Array Research Platform for Engineering and Testing) crossbar architecture. I will then present a machine-learning approach for tracking and compensating experimentally observed gate-voltage drifts, enabling quantitative analysis of charge-noise dynamics and improved long-term device stability. Next, I will introduce GPU-accelerated simulation frameworks for large-scale dataset generation and automated device tuning, enabling fast and accurate modelling of quantum-dot arrays. Finally, I will show how millisecond-scale surrogate electrostatic simulations enable the inverse design of gate-defined quantum-dot devices. Together, these methods establish a machine-learning pipeline for the design, characterisation, operation, and benchmarking of semiconductor spin-qubit platforms.