Quantum Engineering with Levitated Systems

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The quest to build larger and more massive quantum machines probes regimes of quantum mechanics never explored previously. Quantum systems with large mass permits one to explore the interaction of quantum with gravity, the use of such sensitive fragile systems as precision acceleration and inertial sensors, and potential long lived components in quantum information technologies. Researchers have developed many techniques towards the trapping and cooling of nano-micron scaled objects but in this talk I will discuss the advantages of magnetic trapping [1–3]. Magnetic trapping can be achieved completely passively without the need for high power lasers used in optical trapping, or the rapidly oscillating electromagnetic fields used in Paul traps. This complete passive type of trap heralds the potential for very low noise levitation and the creation of ultra-high-motional-Q massive oscillators [4,5]. Such oscillators may be put into motion superposition states via many techniques and have the potential to be the largest Schrodinger Cats created to date. In this talk I will describe some recent theoretical works related to this topic including the use of Machine Learning to improve feedback cooling of the motion [6], methods to cool and spin-up levitated magnonic crystals [7], and proposals to create massive motional superpositions using either superconducting qubits or spin forces provided by single or an ensemble of NV defects in diamond. For the latter we present a new error mitigation technique which can homogenise the microwave (MW) transitions and extend the MW coherence times of an ensemble of NV defects.

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