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Coherent quantum measurement for low-temperature detectors

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It is widely accepted that we are in the midst of a second quantum revolution. The first quantum revolution explained the nature of physical reality, and provided much of the technology that makes the modern world possible. The second quantum revolution is deploying modern tools to manipulate and control coherent quantum systems for computation, simulation, communication, and sensing / measurement. This new revolution is now improving low-temperature detectors, and its impact is likely to grow rapidly in the next years. Coherent quantum techniques that are starting to be deployed in low-temperature detectors include superposition, entanglement, squeezing, backaction evasion, and quantum non-demolition measurement of photon number.

Quantum sensing techniques can impact low-temperature detectors in multiple ways. First, they can be used to improve the sensitivity of individual sensing elements, often to better than the Standard Quantum Limit, enabling measurements that were previously impossible. Second, they can be used to improve the performance of the readout / multiplexing electronics used to read out low-temperature detectors. Eventually, they will be used for coherent quantum networking of large arrays of entangled low-temperature detectors.

While these techniques will have broad impact, some of their earliest applications are in the field of Particle Physics, which can be fundamentally limited by detector sensitivity. Low-temperature quantum devices can be provably more sensitive than classical devices. Quantum-coherent techniques that use low-temperature detectors are now being developed and deployed to search for ultralight dark matter candidates, including axions and hidden photons, enabling some of the earliest practical applications of the second quantum revolution.

Less than 5 years of experience since completion of Ph.D

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