Absolute quantum advantage in imaging: biological microscopy beyond the quantum limit

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It has been recognised since the 1980s that quantum light sources have the potential to improve the performance of microscopes, enhancing the information that can be extracted from biological systems at fixed photon budget [1]. Indeed, today state-of-the-art microscopes use intense lasers that can severely disturb biological processes, function and viability. This introduces hard limits on performance that only quantum photon correlations can overcome [2]. As such, the development of photodamage evading microscopes are widely considered as a key milestone in quantum technology roadmaps.

In this talk I will report recent work which demonstrates absolute quantum advantage in biological imaging [3]. We show that quantum correlations enable signal-to-noise beyond the photodamage-free capacity of conventional microscopy. Broadly, this represents the first demonstration that quantum correlations can allow sensing beyond the limits introduced by optical intrusion upon the measurement process. We achieve this in a coherent Raman microscope, which we use to image molecular bonds within a cell with both quantum-enhanced contrast and sub-wavelength resolution. This allows imaging of biological structures that are inaccessible using classical light. Coherent Raman microscopes allow highly selective biomolecular finger-printing in unlabelled specimens, but photodamage is a major roadblock for many applications. By showing that this roadblock can be overcome, our work provides a path towards order-of-magnitude improvements in both sensitivity and imaging speed.

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