QUANTUM ENHANCED SUPERRESOLUTION MICROSCOPY

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Far-field optical microscopy beyond the Abbe diffraction limit, making use of nonlinear excitation (e.g. STED), or temporal fluctuations in fluorescence (PALM, STORM, SOFI) is already a reality. In contrast, overcoming the diffraction limit using non-classical properties of light is very difficult to achieve due to the fragility of quantum states of light. Here, we experimentally demonstrate superresolution microscopy based on quantum properties of light naturally emitted by fluorophores used as markers in fluorescence microscopy. Our approach is based on photon antibunching, the tendency of fluorophores to emit photons one by one rather than in bursts. Although a distinctively quantum phenomenon, antibunching is readily observed in most common fluorophores even at room temperature.

This nonclassical resource can be utilized directly to enhance the imaging resolution, since the non-classical far-field intensity correlations induced by antibunching carry high spatial frequency information on the spatial distribution of emitters. Detecting photon statistics simultaneously in the entire field of view, we were able to detect non-classical correlations of the second and third order, and reconstructed images with resolution significantly beyond the diffraction limit [1].

Alternatively, we demonstrate the utilization of antibunching for augmenting the capabilities of localization-based superresolution imaging in the presence of multiple emitters, using a novel detector comprised of an array of single photon detectors connected to a densely packed fiber bundle [2]. These features allow us to enhance the spatial and temporal resolution with which multiple emitters can be imaged compared with other techniques that rely on CCD cameras.

[1] O. Schwartz, et al., “Superresolution microscopy with quantum emitters,” *Nano letters*, **13**, 5832–5836 (2013).

[2] Y. Israel et al., “Quantum correlation enhanced super-resolution localization microscopy”, https://arxiv.org/abs/1609.00312.