Super-resolution imaging with plasmonic nanoparticles

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For two decades the diffraction limit has not been the ultimate bound to resolution in far-field fluorescence microscopy [1].The idea of sequentially or stochastically switching between on and off fluorescent states in single dye molecules, followed by their spatial localization, had allowed the development of new nanoscopes with unprecedented resolution for optical imaging techniques.

In this context, stimulated-emission-depletion (STED) nanoscopy remains the fastest and the most suitable technique for tracking the dynamics of small organisms. This technique uses stimulated emission to turn off the spontaneous fluorescence emission of the dye molecule. In a typical STED nanoscope, a focused excitation beam is spatially overlapped with a doughnut-shaped beam that de-excites emitters to the ground state everywhere except for within the centre of the doughnut providing diffraction-unlimited resolution in the transverse plane. By increasing the power of the doughnut beam the emission region can be reduced up to a point thus allowing theoretically subnanometer resolution [2].

However, in practise, problems appear when high-power lasers are employed such as photo-bleaching of the dyes and increasing set-up costs. Employing a high power depletion beam is also a strong limitation for parallelizing the STED measurements, thus preventing ultra-fast super-resolution measurements.

In this work we show the possibility to locally enhance the power of the depletion beam by coupling it with the plasmon resonance of metallic nanoparticles. Employing fluorescent-labelled metallic nanoparticles we achieve high depletion intensities with low laser powers by exploiting the near-field enhancement occurring near the nanoparticles [3, 4]. Our scheme may allow improvement of existing STED nanoscopes and assist in the development of low-power, ultra-fast, low-cost nanoscopes. This has the potential to increase the availability of STED nanoscopes and lead to a significant expansion of our understanding of biological and biochemical phenomena occurring on the nanoscale.

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