ZERNIKE INSTITUTE COLLOQUIUM

Thursday, May 7th, 2015

16:00h, Lecture Hall: 5111.0080

Coffee and cakes from 15:30h

On phase and interfernce: Ultrasensitive coherent detection of single biomolecules and quantum emitters

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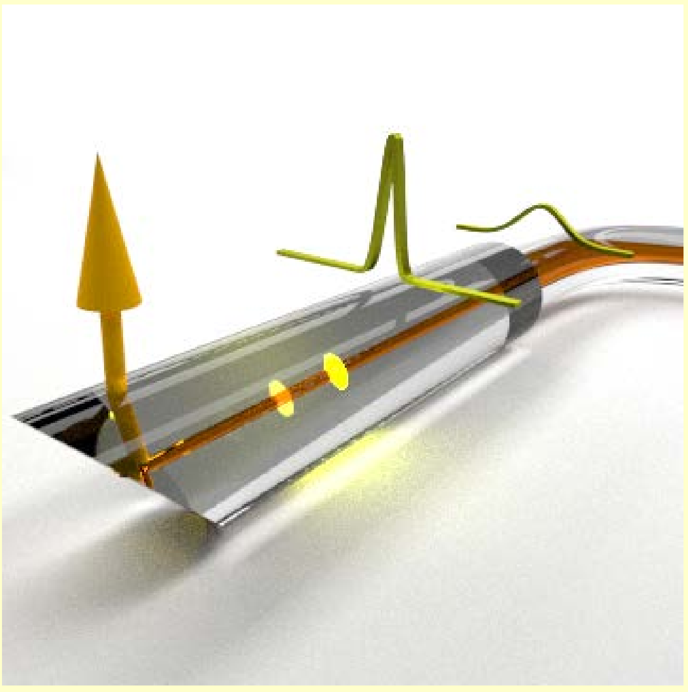
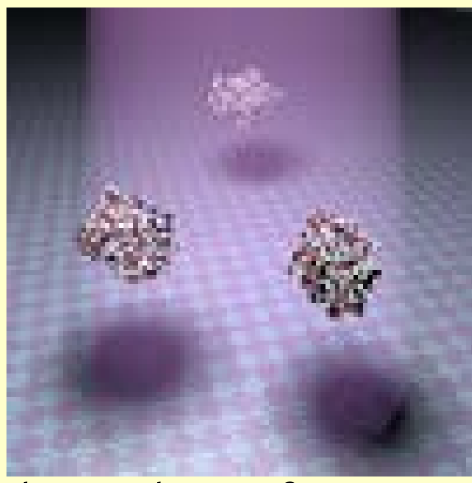
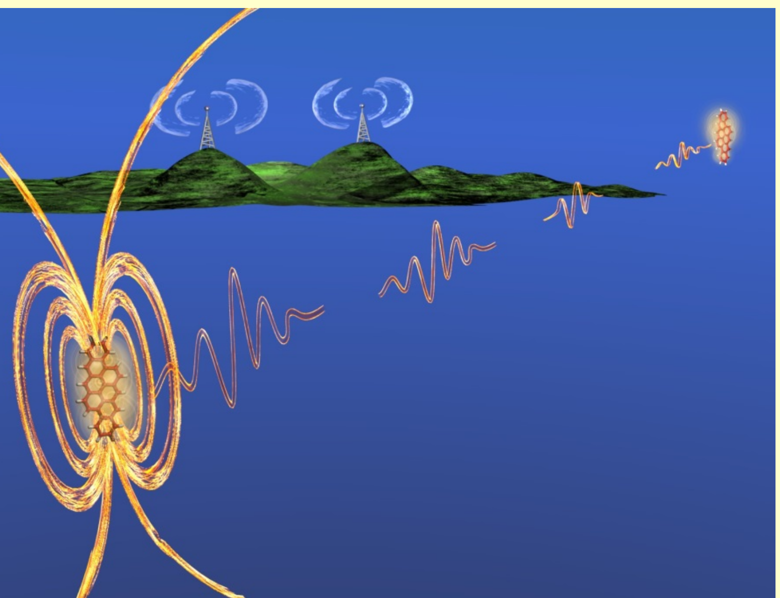


Optical detection has played a central role in many areas of scientific research and has even reached single-atom and single-molecule sensitivity in the past three decades. However, these works have relied on the detection of fluorescence, which is an inherently incoherent process. Many schemes in quantum information processing rely on the preservation of coherence and phase information in the system. Furthermore, considering that fluorescence often suffers from photobleaching, there has been a large effort to explore other optical detection techniques. In this presentation, I shall discuss our advances in fluorescence-free coherent detection of quantum emitters, nanoparticles and biomolecules.



Several years ago, we showed theoretically that in the linear excitation regime, an atom can block a propagating light beam by up to 100% [1]. In the first part of this talk, I present an overview of our experimental work on the efficient interaction of light and single organic molecules at cryogenic temperatures in the near field [2] or through strong focusing [3]. We will see that such solid-state emitters can attenuate [2, 3] and phase shift [4] a laser beam. Furthermore, I shall report on the direct long-Distance communication of two quantum emitters, where single photons are funneled in and out of molecules using lenses of high numerical aperture [5]. We will see that the key concept for efficient photon-atom interaction is mode matching and that optical antennas can be used to change the dipolar pattern of a quantum emitter. For example, we will examine the efficient coherent coupling of single molecules to a dielectric nanoguide [6].



In the second part of this presentation, I shall show that the same concepts discussed above can be exploited for the ultrasensitive and direct detection of single gold nanoparticles [7, 8], viruses [9] and proteins [10].

References

[1] G. Zumofen, et al., *Phys. Rev. Lett.* **101**, 180404 (2008).; [2] I. Gerhardt, et al., *Phys. Rev. Lett.* 98, 033601 (2007).; [3] G. Wrigge, et al., *Nature Physics* **4**, 60 (2008).; [4] M. Pototschnig, et al. *Phys. Rev. Lett.* **107**, 063001 (2011).; [5] Y. Rezus, et al., *Phys. Rev. Lett.* **108**, 093601 (2012).; [6] S. Faez, et al., *Phys. Rev. Lett.* **113,** 213601 (2014).; [7] K. Lindfors, et al., *Phys. Rev. Lett.* **93,** 037401 (2004).; [8] C.-L. Hsieh, S. Spindler, J. Ehrig, V. Sandoghdar, *J. Phys. Chem. B* **118**, 1545 (2014).; [9] P. Kukura, et al., *Nature Methods.* **6,** 923 (2009).; [10] M. Piliarik and V. Sandoghdar, *Nature Communications* **5**, 4495 (2014).

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