

Single Molecules and Nanoparticles as Optical Probes in Nanoscience

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The optical detection and study of single molecules and other nano-objects provide unique insights into their dynamics and that of their surroundings [1]. They also relate to several branches of physics, as I shall illustrate with some recent experiments. The lifetime-limited lines of single molecules at cryogenic conditions probe acoustic [2] and electric perturbations, making them attractive for quantum optomechanics. We recently studied the dynamics of vapor nanobubbles created in the liquid surrounding a single immobilized gold nanosphere. These nanobubbles form in an instable, explosive process before collapsing and can react to sound waves [3]. Photothermal microscopy opens the study of non-fluorescent absorbers, down to single-molecule sensitivity [4]. The high signal-to-noise ratio enables local plasmonic and chemical probing [5] (see Fig. 1). Fluorescence enhancements in excess of thousand-fold can be observed in a gold nanorod near field at resonance. Gold nanorods also possess intriguing magnetic properties which can be studied through alignment in a strong magnetic field [6]. Experiments on single nanorods would clarify the origin of their giant diamagnetic susceptibility.

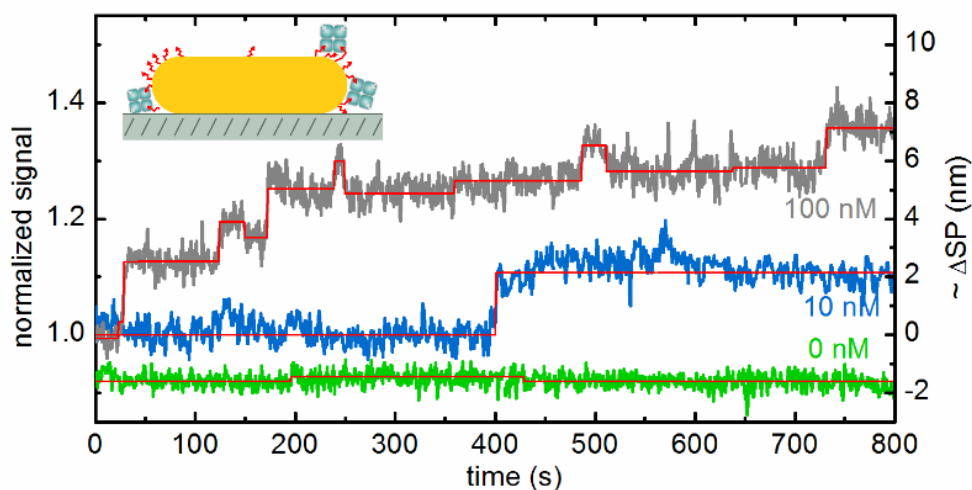


Figure 1: Example of an absorption trace of a single gold nanorod showing binding and unbinding events of single proteins [5]. The binding events become more frequent as the protein concentration in the solution increases.

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3. L. Hou et al., *New J. Phys.* **17** (2015) 013050.
4. A. Gaiduk et al. *Science* **330** (2010) 353.
5. P. Zijlstra et al., *Nature Nanotech.* **7** (2012) 379.
6. P. van Rhee et al., *Phys. Rev. Lett.* **111** (2013) 127202.