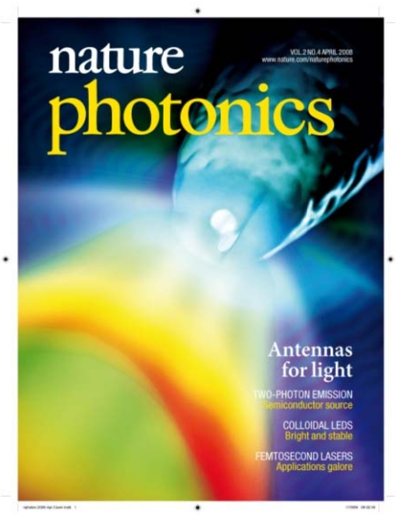
Manipulating light and heat at the nanoscale with metallic nanoparticles

Fernando D. Stefani

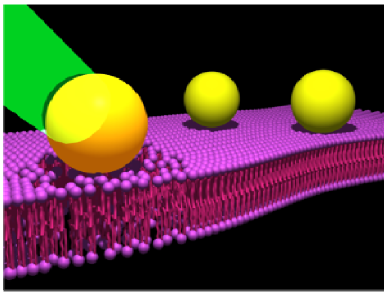
Departmento de Física
Universidad de Buenos Aires

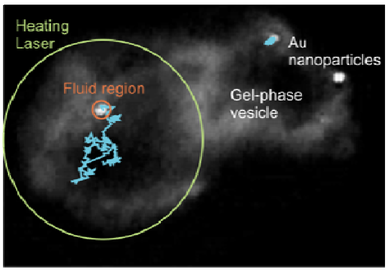
The optical properties of metallic nanoparticles are marked by collective resonances of their electrons. These resonances depend strongly on the composition and shape of the nanoparticles and are accompanied by strong light scattering and absorption.

Light is usually controlled by redirecting the wave fronts of propagating radiation with lenses, mirrors, and diffractive elements. This type of manipulation relies on the wave nature of electromagnetic fields and is therefore not suitable to control fields on the subwavelength scale. Radio- and microwave technology on the other hand makes use of antennas to manipulate electromagnetic fields on the subwavelength scale and interfacing efficiently between propagating radiation and localized fields. An optical analogue is therefore of great interest because it would allow the manipulation of light at the nanoscale. In the first part of this talk I will present calculations and experimental results that demonstrate how the strong light scattering by metallic nanoparticles enables their use as resonant optical nano-antennas for single emitters [1,2,3].



The second part of the talk is based on the strong light absorption by metallic nanoparticles which enables their use as optically driven heat sources. Currently, a number of high resolution techniques provide detailed information about the structure and pathways of nanoscale (bio)systems. Full understanding of their function requires additional energetic information, which in turn demands the development of remotely controlled nanoscopic sources of heat. I will present experiments that illustrate the use of single gold nanoparticles as optically controlled nano heat sources. We rapidly deposited controlled amounts of heat in nanoscopic regions of defined size of a phospholipid membrane [4], inducing and controlling nanometric reversible gel-fluid phase transitions in the membranes. We exploit the optical control over the phase transition to determine the velocity of the fluid phase front into the gel phase membrane and to guide the nanoparticles to specific locations.





[1] T H Taminiau, F D Stefani, F B Segerink, and N F Van Hulst, Nature Photonics **2**, 234-237 (2008).
[2] T H Taminiau, F D Stefani, and N F Van Hulst, New Journal Of Physics **10**, 105005 (2008).
[3] Tim H Taminiau, Fernando D Stefani, and Niek F Van Hulst, Optics Express **16**, 10858-10866 (2008).
[4] A S Urban, M Fedoruk, M R Horton, J O Ra, F D Stefani, and J Feldmann, Nano Letters **9**, 2903-2908 (2009).