Linear and ultrafast plasmonics with individual nanoparticles

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The versatile and adjustable properties of metal nanoparticles, associated to the emergence of novel optical, electronic, acoustic and thermal responses with size reduction, have large fundamental and technological interests. In the optics domain, the main signature of confinement is the appearance of surface plasmon resonances (SPR) enhancing the nanoparticle optical response at specific wavelengths. The SPR characteristics are determined not only by the nanoparticle composition, structure, size and shape but also by its local environment (a substrate, solid or liquid medium, molecules or other nanoparticles). The latter dependence can be exploited for sensing purposes or for tuning the optical properties of a nanoparticle by controlling its environment conditions. In this context, our talk will address the effects of pressure and temperature on the linear and ultrafast optical properties of a metal nanoparticle.

Plasmonic ultrafast spectroscopies are nowadays experimentally accessible at single-particle level [1,2]. In the first part of the talk, we discuss the linear optical response of an individual gold nanoparticle under extreme conditions of high pressure. By combining the spatial modulation spectroscopy (SMS) technique [3,4] with a miniaturized diamond anvil cell (DAC), quantitative measurement of the optical extinction cross-section of a gold nano-bipyramid were performed under increasing pressure up to 10 GPa. The evolutions of the SPR spectra with pressure are interpreted by analytical model and finite-element-method simulations, demonstrating the impact of pressure-induced dielectric changes in both the metal and its local environment.

In the second part of this talk, the ultrafast dynamics of a metal nano-object will also be discussed, with a focus on mechanical and thermal energy transfer at the interface with its local environment, a key technological issue with the development of devices in the nanometric size range. We experimentally investigated the heating and subsequent cooling of metal nano-objects by using femtosecond time-resolved spectroscopy [5,6]. SPR modifications induced by thermal excitation and launching of mechanical vibrations were analyzed using numerical finite-element approach [7]. Here, we will discuss the acoustic vibrations of a single gold nanodisk deposited on a substrate, and show the impact of the object morphology on their mechanical quality factor.

References

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