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Enhancement of the low frequency Raman scattering of a single polystyrene nanoparticle with a random metallic film

Physical properties of nano-objects depend on their nature and morphology, but not only. Different interactions with the environment take place. For example, surface plasmon resonances (SPR), excitons, or acoustic vibrations of nanoparticles (NPs) are all sensitive to the surrounding medium. Interaction between nano-objects can significantly improve environment sensitivity. For two identical metallic NPs in close vicinity (not in contact), there is a red-shift of the SPR and a huge increase of the electromagnetic field in-between them. This is commonly exploited for detection based on optical absorption or surface enhanced Raman spectroscopy (SERS). This last experiment is based on one phenomenon: the local enhancement of electromagnetic field induced on metallic nanostructured layer by a surface plasmon resonance. If the global phenomenology of the effect is understood, the exact nature of enhancement is not clearly described. In order to answer to this question, we propose a new experimental approach to realize Surface Enhanced Raman Spectroscopy in Low Frequency domain (LF-SERS). Using Total Internal Reflection geometry, the student will realize LF-SERS of a single polystyrene nanoparticle. This study should permit to quantify the enhancement of the Raman scattering efficiency by a random metallic film. This new approach will allow probing finely the nature of the plasmonic modes responsible of the enhancement and so going deeper in the understanding of SERS effect at low frequency.

In a first step, the student will have to acquire the Low Frequency Raman spectra of a single polystyrene nanoparticle without enhancement using a set-up already developed for the low frequency Raman spectroscopy of single gold nanoparticle. This experiment will permit to measure the scattering cross section of a single nanoparticle. In a second step the student will have to characterize the enhancement factors obtained on randomly nanostructured films as a function of the angle of incidence. For this purpose, the plasmonic modes of these structures will be initially characterized using Total Internal Reflection spectroscopy. Two types of structures will be probed: random metallic film realized by evaporation or bi-dimensionnal layers of small metallic nanoparticles. Finally, polystyrene nanospheres will be deposited on the random films in order to characterize the efficiency of enhancement as a function of the plasmonic mode excited, with the main objective to characterize a single nanosphere on the SERS substrate. This will aim to identify the nature of the plasmonic modes responsible of the maximum enhancement, and thus to improve the understanding of the plasmon-vibration coupling.

Technics used:
Low frequency Raman/Brillouin Spectroscopy, Total Internal Reflection Microscopy, Confocal microscopy