Metal nanostars in SERS & Optical Heating

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Metal nanoparticles exhibit a rich optical phenomenology due to the excitation of localized surface plasmons (LSPs). Concentrating light into small volumes leads to fascinating phenomena. LSPs supported by pairs of nanoparticles with a small gap between them are able to greatly amplify local EM fields and the photonic local density of states, making these structures ideal for use in SERS and surface-enhanced fluorescence. Metal nanoparticles might also be suitable for potential biological applications, because they enable the tracking of emission from markers in cells with sub-diffraction limit resolution, as well as the destruction of cancer cells using the resistive heating of resonant nanoparticles. In general, most of the appealing optical properties of metal nanoparticles typically manifest themselves in optically coupled nanoparticles with stronger LSPs. In this regard, we have investigated theoretically and numerically the optical properties of isolated nanoparticles with the aim of exploring how complex shapes might yield similar or improved phenomenology.

First, in connection with SERS, we have studied so called nanostars or nanoflowers, as described by, respectively, a 3D supershape formula [1] without axial symmetry and low-order Chebyshev 2D nanoparticles [2]. Large field intensity enhancements are obtained both at the interstices between nanoflower petals and at the nanostar tips, which make these Ag nanostars/nanoflowers specially suitable to host molecules for SERS spectroscopy and sensing applications, without the commonly needed aggregation. Moreover, based on a simple model for temperature increase obtained from the calculated absorption cross section, Au nanostars have been shown [3] to perform more than an order of magnitude better that Au nanospheres of equivalent size, due to their LSP in the near-IR (see Fig. 1). Actually, these features hold promise for applications in photothermal cancer therapy.

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