Surface plasmon resonance in metallic nano-particles: size, shape, surrounding.

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Remarkable optical properties of metallic nano-particles, connected to plasmon oscillations, make them prospective material for applications in photonics and photovoltaics. Observed enhancement of absorption and scattering of light on nano-particles could be used to enhance efficiency of solar cells, detect single molecules with surface-enhanced Raman scattering or create waveguides transporting the light in nano-scale [1].

Experiment shows that surface plasmon resonance (SPR) [2] strongly depend on nano-particle size, shape and refractive index of surrounding media. Proper understanding of those correlation is then crucial for design of future plasmon devices. Classical electrodynamic description of this phenomena in case of sphere was done by Gustav Mie in 1908, nevertheless the extinction spectra dependence of nano-particles size is introduced phenomenologically via dielectric function [3]. The microscopic mechanism is not well described yet.

In paper we develop microscopic model of SPR in sphere within random phase approximation, where plasmon dissipation is introduced by electron scattering inside the metal and electromagnetic field irradiation described by Lorentz friction. Dependence on nano-sphere radius for both those processes is investigated in aim to optimize nano-particle size for largest attenuation rate. We investigate also the SPR wavelength dependence on nano-sphere radius. Obtained results are compared with classical electrodynamics calculations by Finite element method (FEM) provided by COMSOL Multiphysics 5.0 with Wave Optics module, Mie theory and experimental data for gold, silver and copper nano-particles. We present also numerical calculations of extinction spectra as a function of particle size and surrounding dielectric media for sphere, ellipsoid and rod shape.

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