Modeling the Interaction of Light With Plasmonic Nanoparticles

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Introduction: Plasmonic nanoparticles have received increased interest due to their numerous potential applications in the field of optics and optoelectronics. Currently such metallic nanoparticles are applied in semiconductor devices, such as light emitting diodes (LEDs) and solar cells. The optical behaviour of a single plasmonic nanoparticle is can be easily described with several analytic or semianalytic methods (e.g. quasistatic approximation, Mie-theory). However for modeling the interaction of a nanoparticle dimer with polarized light we have to use numerical simulation. In this work, we modeled the interaction of linearly polarized light with two silver nanoparticles with 5 nm radius. We calculated the absorption cross section for two different polarization, and for different spacing between the particles.

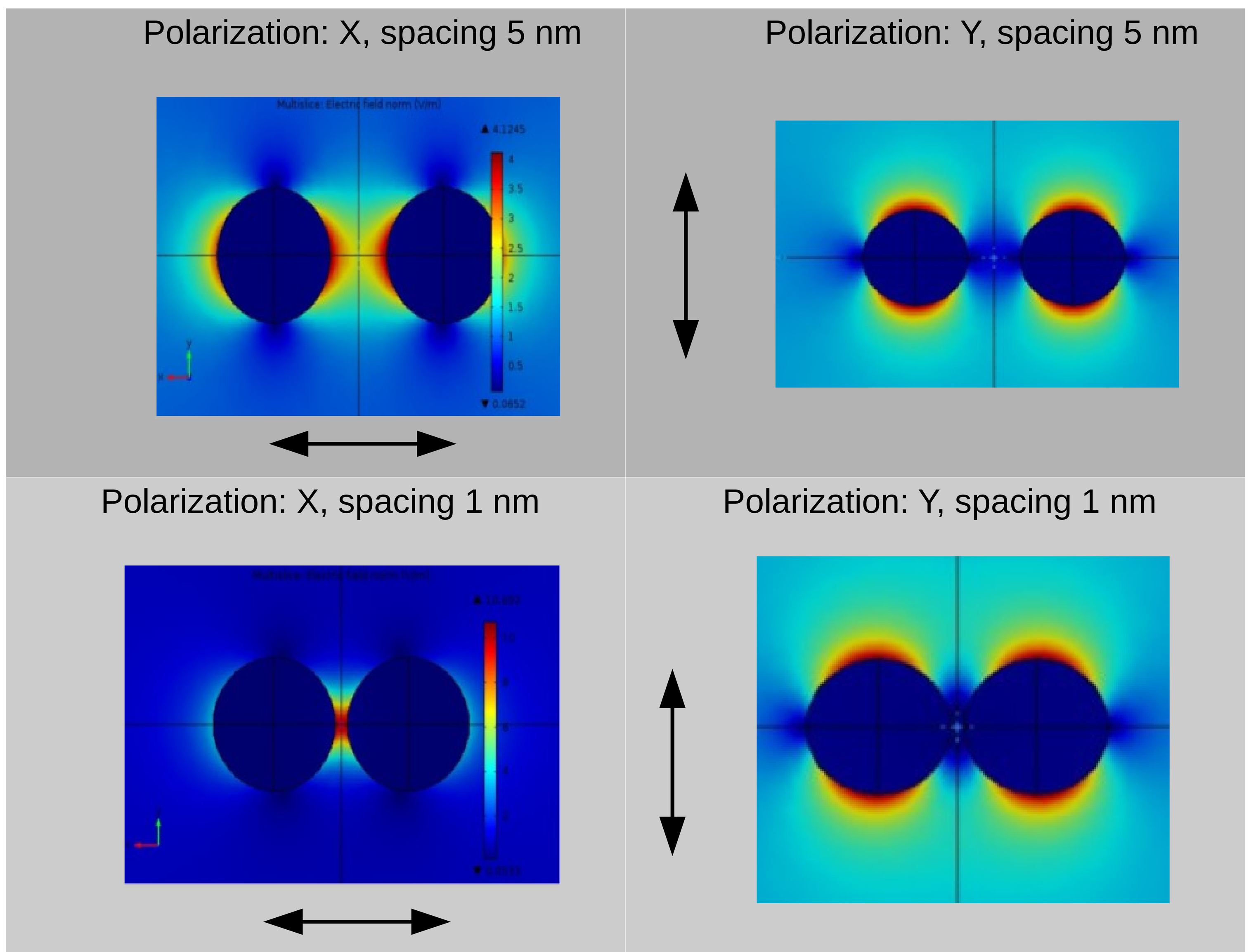

Figure 1. The norm of the electric field between the two silver nanoparticles, in different cases.

Computational Methods: We solved the frequency depedent electromagnetic wave equation to model this problem:

$$\nabla\times\mu_r^{-1}(\nabla\times\vec{E})-k_0^2\left(\epsilon_r-\frac{j\sigma}{\omega\epsilon_0}\right)\vec{E}=0$$

For our simulations we used the RF (Radio Frequency) Module of COMSOL Multiphysics®.

In our model we used the following built-in features:

- For obtaining the scattering cross sections, we solved the electromagnetic wave equation with the **scattered field formalism**.
- We closed our calculation volume with **scattering boundary condition**
- For describing the strong plasmonic field around the particles we used the **flexible meshing** possibilites.
- We used the built-in **postprocessing possibilities** for obtaining the absoption and scattering cross sections

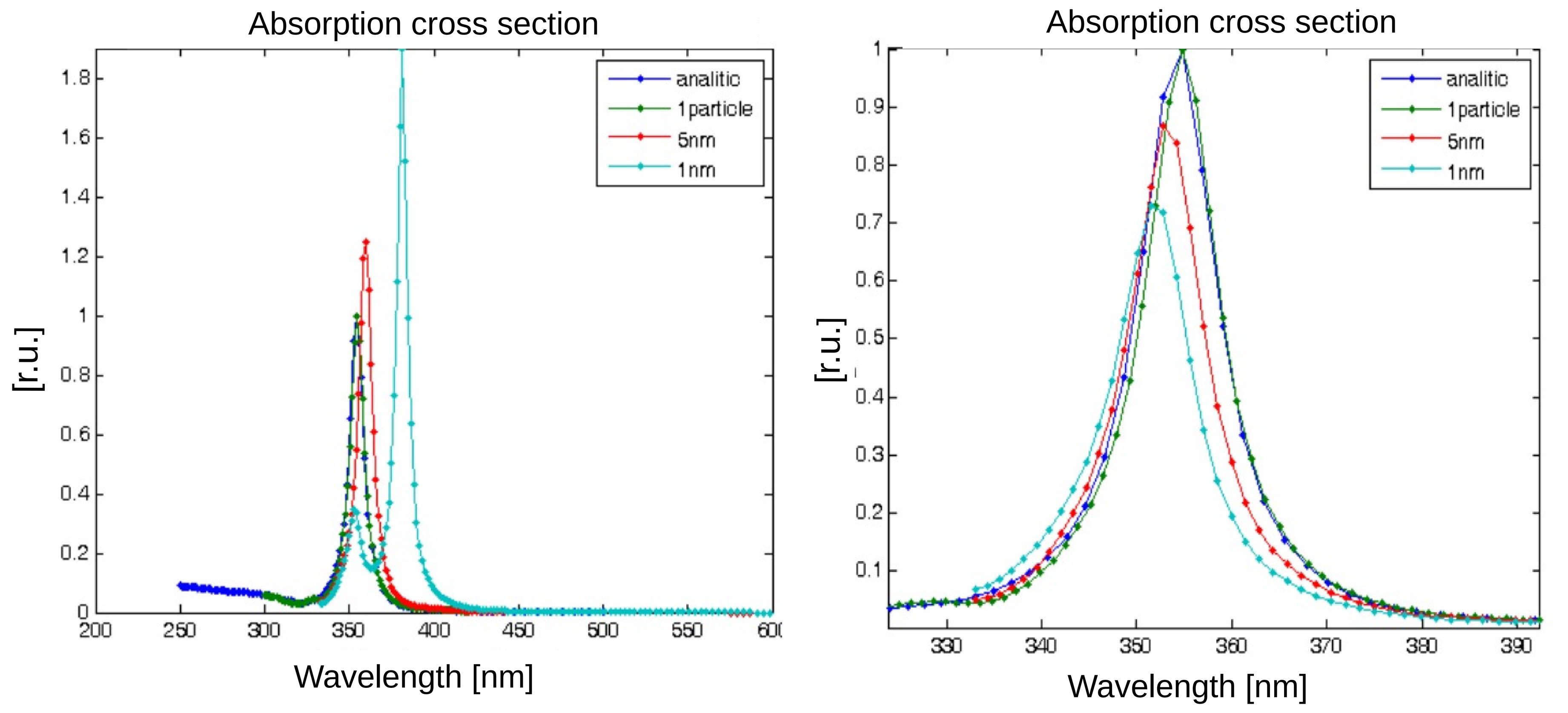

Figure 2. The wavelength dependence of the absoption cross section for polarization X (left) and Y (right).

Results: The results show that the interaction of nanoparticles is very sensitive for the polarization and for the interpartical spacing. When the polarization is perpendicular to the particles (Y),a weak blue shift can be observed in theplasmon resonance peak in the absorption cross section. However when the polarization is paralell to the particles (X), the plasmon resonance peak in the absorption cross section, shifts to the red. In this cace the interaction is much more stronger. When the interparticle spacing is 1 nm, a higher order plasmon resonance peak can be observed.

Conclusions:

We showed, that the interaction of nanoparticles is very sensitive for the polarization and for the interpartical spacing. In the future we would like to investigate the interaction between nanoparticles, which are situated on semiconductor surface.

References:

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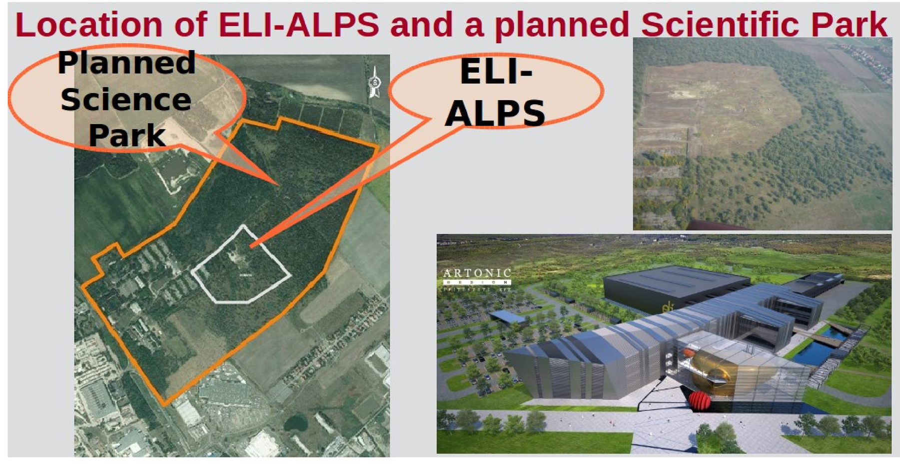

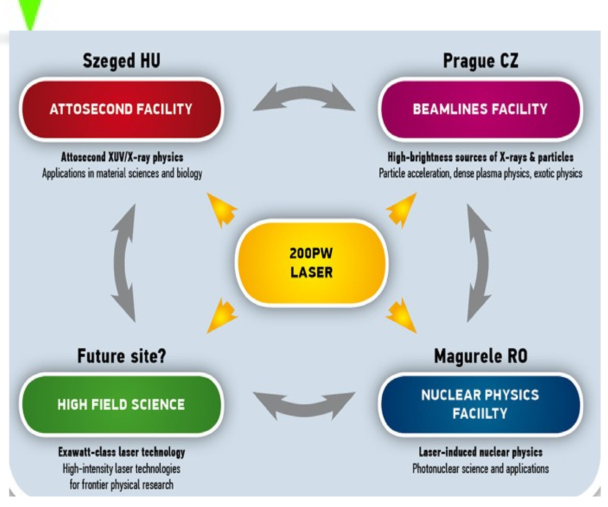

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