ABSORPTION AND SCATTERING OF LIGHT IN A DIMER OF THE “SOLID METALLIC NANOCYLINDER – METALLIC NANOTUBE” TYPE

V. I. Reva[1], A. V. Korotun[1,2], O.O. Shyrokopoias[1]

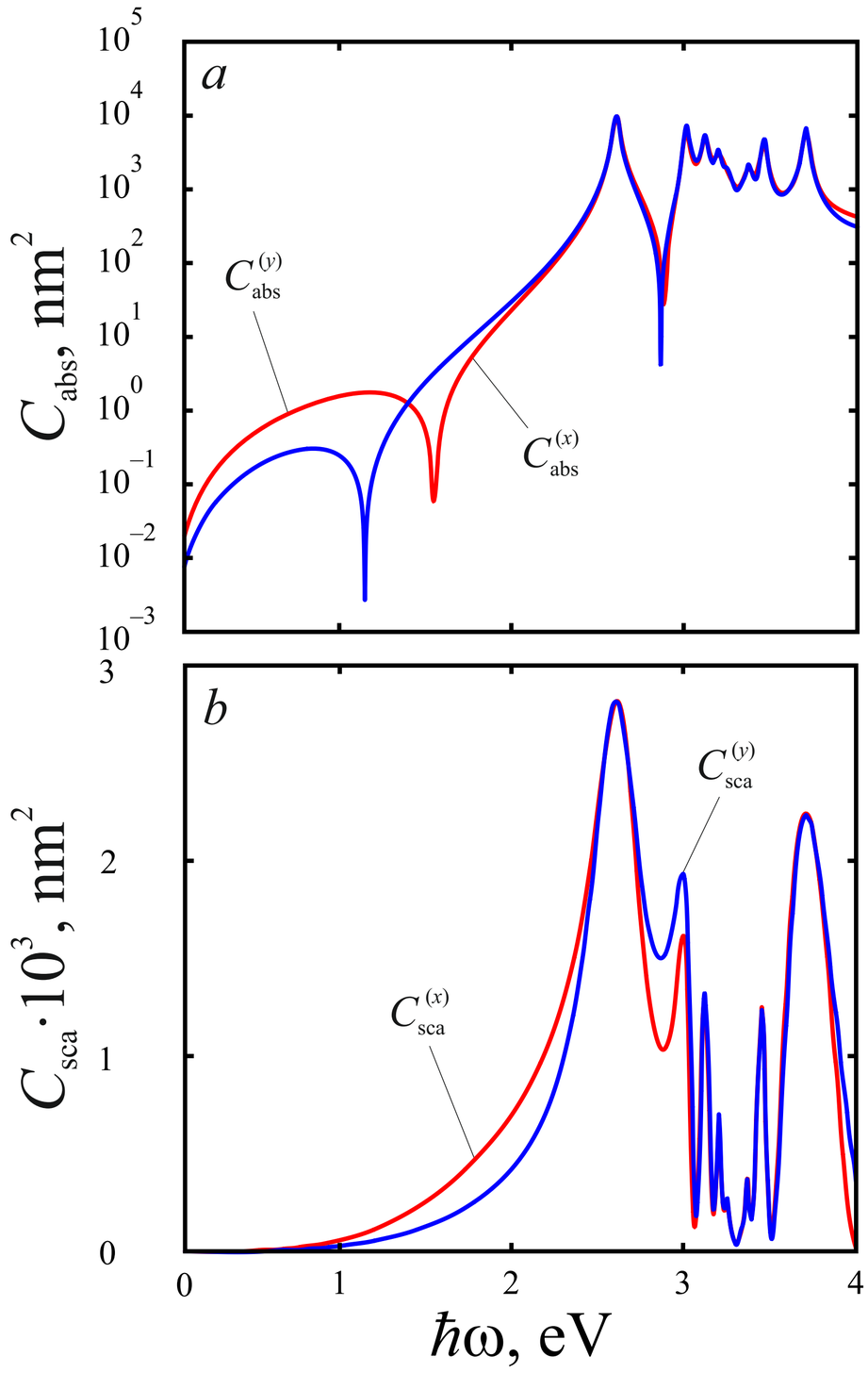
[1]*National University Zaporizhzhia Politechnic, 64 Universytetska Str., Zaporizhzhia 69011, Ukraine*

[2]*G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine,36 Academician Vernadsky Blvd., Kyiv 03142, Ukraine*

Abstract

It is well known that a significant enhancement of local electric fields and the formation of “hot spots ” are possible in the gaps between metallic nanostructures. Therefore, the study of optical phenomena in dimers of nanoparticles with different shapes is of great practical interest.

Figure 1



Frequency dependences of the absorption (a) and scattering (b) cross sections for incident light of different polarizations

Statement of the problem

We shall investigate the absorption and scattering of light in a dimer of a cylinder and a nanotube parallel to each other. The transformation plasmonics approach allows us to obtain the following relations for the absorption and scattering cross-sections of horizontally (x) and vertically (y) polarized radiation for the nanosystem under consideration.

$$C_{\text{abs}}^{(x,y)} = \frac{\omega}{c}\sqrt{\epsilon_{\text{m}}}V\frac{\operatorname{Im}\xi_{xy}}{\left|1+\mathrm{I}\,\pi\left(\frac{\omega D}{2c}\sqrt{\epsilon_{\text{m}}}\right)^2\xi_{xy}\right|},$$

$$C_{\text{sca}}^{(x,y)} = \frac{1}{6\pi}\left(\frac{\omega}{c}\sqrt{\epsilon_{\text{m}}}\right)^4 V^2\left|\frac{\xi_{xy}}{1+\mathrm{I}\,\pi\left(\frac{\omega D}{2c}\sqrt{\epsilon_{\text{m}}}\right)^2\xi_{xy}}\right|^2, \qquad (1)$$

where

$$\xi_x = \pi\,\mathrm{e}^{\alpha}\sum_{l=1}^{\infty}\frac{\eta^{2l}+\mathrm{e}^{\alpha}-\mathrm{e}^{\alpha}\,\eta^{2l}\left(1+\eta^{2l}\operatorname{ch}\alpha\right)}{\eta^{4l}-\mathrm{e}^{2\alpha}\left(1+\eta^{6l}-\eta^{2l}\right)},$$

$$\xi_y = \pi\,\mathrm{e}^{\alpha}\sum_{l=1}^{\infty}\frac{\eta^{2l}-\mathrm{e}^{\alpha}+\mathrm{e}^{\alpha}\,\eta^{2l}\left(1-\eta^{2l}\operatorname{ch}\alpha\right)}{\eta^{4l}-\mathrm{e}^{2\alpha}\left(1+\eta^{6l}-\eta^{2l}\right)}, \qquad (2)$$

$$\alpha = \ln\frac{\epsilon(\omega)-\epsilon_{\text{m}}}{\epsilon(\omega)+\epsilon_{\text{m}}} \qquad \eta = \frac{\sqrt{2+\varrho}+\sqrt{\varrho}}{\sqrt{2+\varrho}-\sqrt{\varrho}} \qquad (3)$$

ω and c are the frequency and speed of light; ϵ_{m} is the permittivity of the surrounding dielectric; $\epsilon(\omega)$ is the dielectric function of the cylinder and nanotube material (determined by the Drude model); l is the multipolarity order; $\varrho = \delta/D$, d is the distance between the cylinder and the nanotube, D is their diameter;

$$V = \frac{\pi}{4}\left(D^2+\left(D-d\right)^2\right)L$$

is the volume of the metallic part of the nanosystem, d is the diameter of the dielectric core of the nanotube, L is the length of the nanotube (cylinder).

Results of calculations and conclusions.

The calculation results (Fig. 1) indicate the presence of a large number of absorption and scattering cross-section maxima arising from the strong interaction of plasmon modes of different multipolarity. Furthermore, it should be noted that the polarization type of the incident light has a weak effect on the absorption and scattering cross sections.