



# ENHANCEMENT OF ELECTRIC FIELDS IN THE GAP BETWEEN TWO METAL NANOPARTICLES. DIPOLE APPROXIMATION



A. V. Korotun<sup>1,2</sup>, V. P. Kurbatsky<sup>1</sup>, H. V. Moroz<sup>1</sup>

<sup>1</sup>National University Zaporizhzhia Politechnic, 64 Universytetska Str., Zaporizhzhia 69011, Ukraine

<sup>2</sup>G.V. Kurdyumov Institute for Metal Physics of the NAS of Ukraine, 36 Academician Vernadsky Blvd., Kyiv 03142, Ukraine

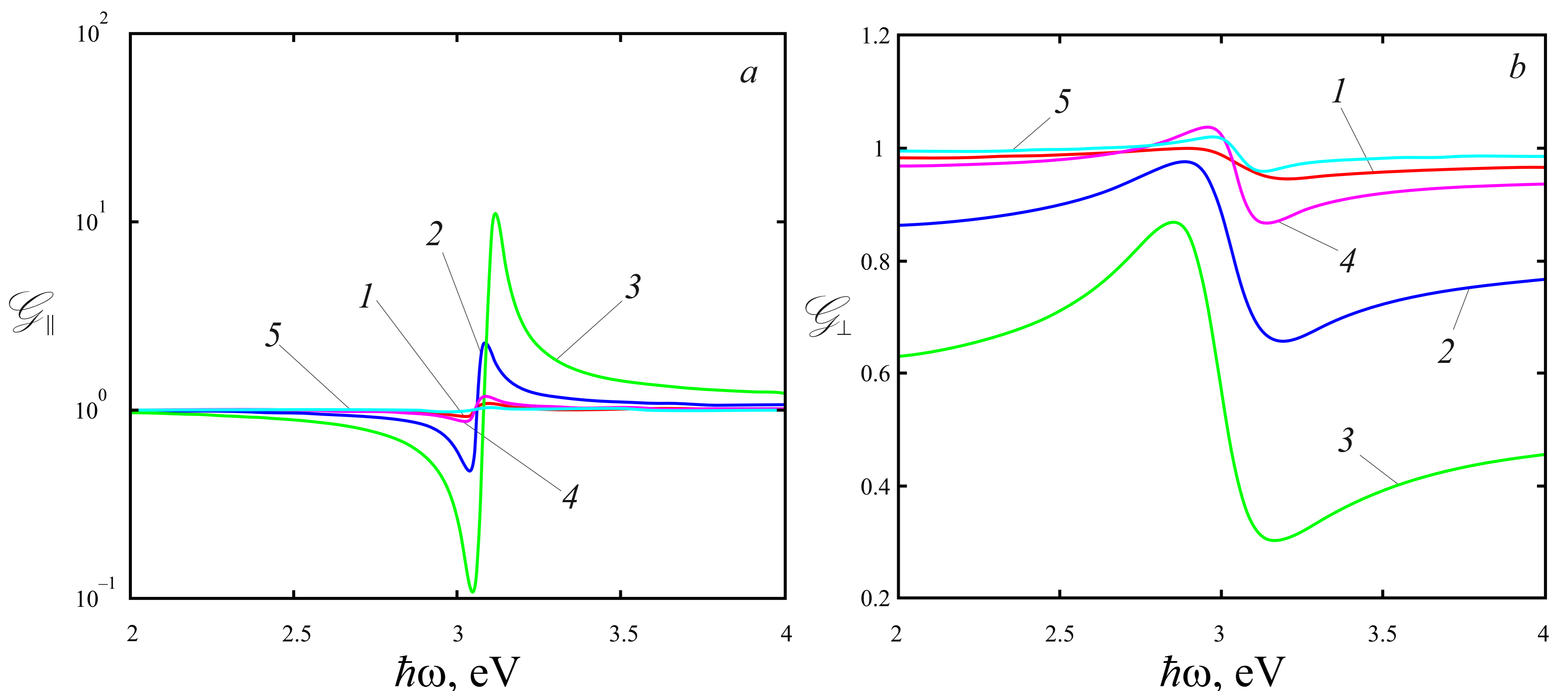
## Abstract

One of the most important applications of plasmonic nanoparticles is their use as optical antennas. This application is possible due to the enhancement of electric fields in the vicinity of nanoparticles when plasmon resonances are excited on their surfaces. The problem of field enhancement near isolated nanoparticles is well studied. However, the scientific literature contains virtually no studies investigating field enhancement in the gap between two nanoparticles. Since such dimeric optical nanoantennas can be used to observe fluorescence or Raman scattering, studying the enhancement of electric fields in the gap between metal nanoparticles of various shapes is relevant.

## Statement of the problem

A rigorous approach to studying the optical response of dimers is the  $\epsilon$ -method, which takes into account the contributions of all multipole modes [1]. However, this method has a significant drawback: it is cumbersome and, consequently, requires a large amount of calculations. It is well known that the main contribution to the optical response of both isolated nanoparticles and their dimers comes from the dipole resonant mode. Therefore, in this study, the diagonal components of the field enhancement tensor in the gap between nanoparticles are calculated using the dipole polarizability tensor.

Figure 1



Frequency dependences of the longitudinal (a) and transverse (b) components of the electric field enhancement tensor in the gap between two prolate spheroidal nanoparticles:  
1 –  $b_i = 10\text{nm}$ ,  $a_i = 100\text{nm}$ ,  $d = 10\text{nm}$ ; 2 –  $b_i = 10\text{nm}$ ,  $a_i = 100\text{nm}$ ,  $d = 20\text{nm}$ ; 3 –  $b_i = 10\text{nm}$ ,  $a_i = 100\text{nm}$ ,  $d = 30\text{nm}$ ;  
4 –  $b_i = 20\text{nm}$ ,  $a_i = 100\text{nm}$ ,  $d = 20\text{nm}$ ; 5 –  $b_i = 40\text{nm}$ ,  $a_i = 100\text{nm}$ ,  $d = 20\text{nm}$ .

## Results of calculations and conclusions.

The calculations were performed for dimers of prolate spheroidal nanoparticles. The calculation results (Fig. 1) indicate the presence of a significant longitudinal enhancement (especially in the vicinity of the optical resonance) and a virtual absence of transverse enhancement. Furthermore, it is shown that the maximum longitudinal enhancement is influenced by the size factor, since an increase in eccentricity (a decrease in the aspect ratio of the minor to major semi-axis of the prolate spheroid) leads to an increase in the maximum value of the electric field enhancement in the gap between the nanoparticles.