APLASMONIC PHENOMENA IN A CHAIN OF TOROIDAL METAL NANOPARTICLES ON A DIELECTRIC SUBSTRATE

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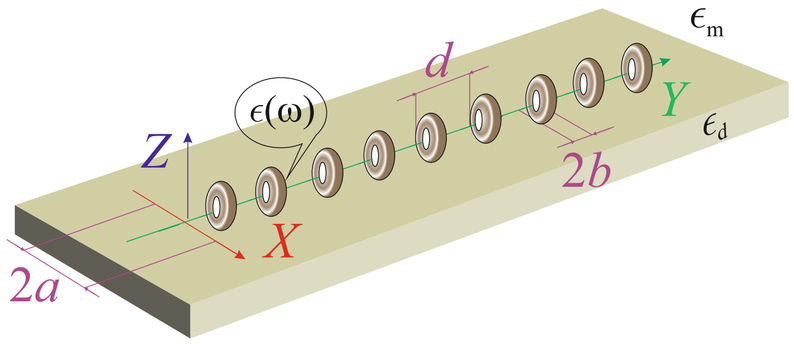
Abstract

Chains of metal nanoparticles of various geometries are currently being actively studied both experimentally and theoretically. This interest stems from their wide range of practical applications. In particular, chains of metal nanoparticles are used as discrete plasmonic waveguides for transmitting modulated signals with a high degree of spatial confinement. Researchers expect that subwavelength spatial localization of optical excitations in plasmonic discrete waveguides will minimize parasitic interactions between the structural elements of the optical circuit. Another advantage of plasmonic chains is the easy tuning of their properties by varying the particle sizes in the chain and the distance between them. The optical response of chains of oblate and prolate spheroids has already been studied [1, 2]. However, plasmonic phenomena in chains of nanoparticles of other geometries remain unexplored, making such research relevant.

Statement of the problem

This paper examines the optical response of a chain of toroidal metal nanoparticles on a dielectric substrate (Fig. 1). The toroids in the chain have a common axis parallel to the plane of the substrate.In the local field approximation, the frequency dependence of the transverse component of the chain polarizability tensor and the size dependence of the chain optical resonance frequency were obtained. Spectral shifts of the maxima of the transverse polarizability imaginary part were compared for the chain and an isolated toroid. The influence of the particle and substrate materials, and surrounding medium on the positions of the chain resonances was studied.

Figure 1



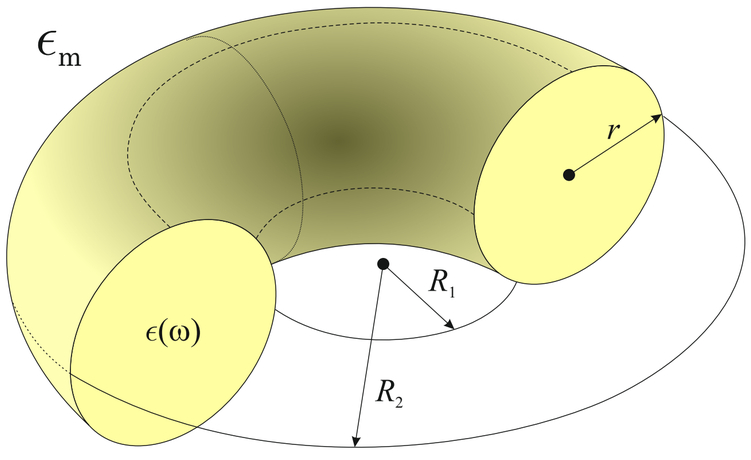
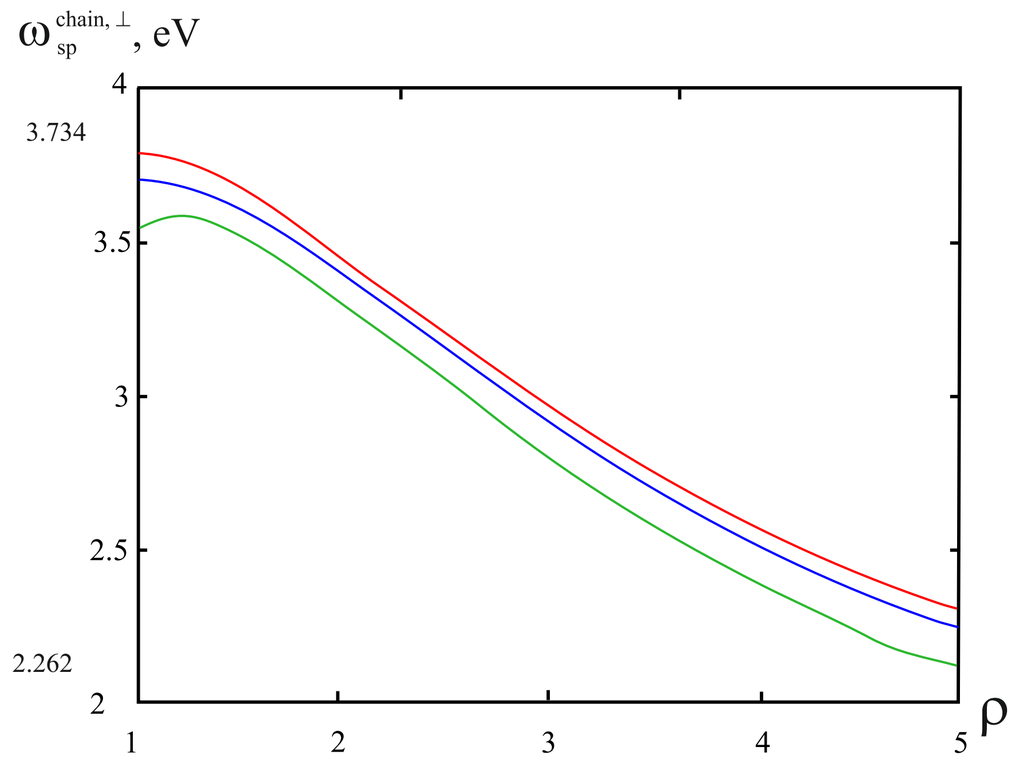


Figure 2



Size dependence of the transverse optical resonance frequency of a chain of nanotori Ag: 1 – r = 5nm; 2 – r = 10nm; 3 – r = 15nm.

Results of calculations and conclusions.

The calculation results (Fig. 2) indicate a significant decrease in the frequency of the chain optical resonance with increasing aspect ratio. Furthermore, for any aspect ratio, the resonant frequency decreases with increasing torus tube radius.

1. M. S. Maniuk, A. V. Korotun, V. I. Reva, I. M. Titov, Cond. Matt. Phys., 27 43701 (2024).
2. M. S. Maniuk, A. V. Korotun, V. P. Kurbatsky, Low Temp. Phys. 51, 143 (2025).