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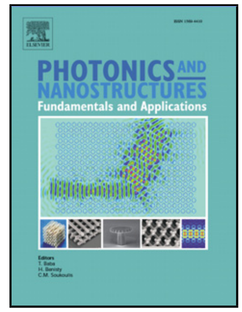


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# The effect of the local field and dipole-dipole interactions on the absorption spectra of noble metals and the plasmon resonance of their nanoparticles

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## Research Highlights

- The impact of dipole-dipole interactions on the absorption spectra of noble metals and their nanoparticles is investigated
- The calculations of the noble metal (Ag, Au and Cu) micro-characteristics are presented
- The difference in the frequency of the resonant absorption of electron oscillators localized in the nanoparticle and the intrinsic frequency of the free electrons in the bulk metal is due to resonant dipole-dipole interactions

ABSTRACT

Based on the Drude-Lorentz model, the effect of free and bound electrons on the optical properties of noble metals and their nanoparticles is analyzed. It is shown that the shifts of absorption bands of plasmons localized in spherical nanoparticles with respect to the zero frequency of free electrons in a bulk metal can be estimated on the basis of the theory of resonant dipole-dipole interactions. The calculation includes account for differences between the effective and average electromagnetic fields. It is established that the difference in oscillator strength for free electrons in the bulk metal, obtained using the Drude-Lorentz model, and the microscopic oscillators in the corresponding spherical nanoparticle, is due to background polarization. This occurs at the expense of high-frequency excitation of the bound electrons. These results show that interparticle interactions in the noble metals in the quasi-static approximation can be regarded as dipole-dipole interactions of point dipoles with a concentration equal to the concentration of free electrons.

## 1. INTRODUCTION

The investigation of the optical properties of metal nanoparticles of various sizes and shapes has attracted a great deal of attention from researchers over the last two decades (see, for example, Refs. [1-5]). Excitation of surface plasmons in these particles has stimulated considerable interest in these materials, since their unique optical properties can be exploited in a variety of devices [6-8]. Possible applications include highly sensitive chemical and biological sensors [9-11], single particle/molecule detection [12], surface enhanced spectroscopy [13,14], waveguiding [4] and lasing [5]. This research has resulted in a number of textbooks and comprehensive reviews, some of which are cited above, devoted to the synthesis and fabrication of a variety of composite systems as well as modelling and characterisation of their linear and nonlinear optical properties. Modelling of the optical properties of small particles is under active development using a modification of the Maxwell-Garnett approximation [2,15] using numerical calculation techniques [16].