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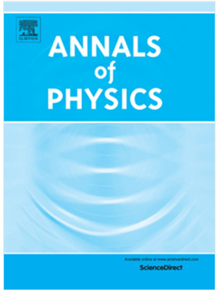

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Quantum Eye: Lattice Plasmon Effect on Quantum Fluctuations and Photon Detection

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ABSTRACT

In this work, arrays of plasmonic nanoparticles coupled to a detector are designed and considered as a quantum eye. In the designed system, the plasmonic nanoparticles have a role like an ommatidium in the artificial compound eye; however, the quantum eye ommatidium acts with different functionality. To better understand this system, we analyze it with the full quantum theory, quantize lattice plasmon generated by the array of plasmonic nanoparticles, and finally derive bosonic operators using Heisenberg-Langevin equations. Moreover, we theoretically derive the radiative and non-radiative losses introduced by this system and examine lattice plasmon effect on spontaneous emission of the quantum dot (Purcell factor). The main goal of this article is to investigate the quantum eye's quantum properties such as quantum fluctuations, which is modeled and analyzed by studying the second-order correlation function. This function exhibits a significant bunching as a function of lattice plasmon optical properties. We can easily manipulate and improve the lattice plasmon optical properties, which dramatically depend on the array geometry. Finally, we study the quantum eye photon detection by a quantum measuring approach and show that the lattice plasmon has a strong effect on quantum properties after the one-count process.

Key words: lattice plasmon, quantum fluctuations, second-order correlation function, nanoparticles array, quantum dot photo-detector, one-count process

Introduction

To develop cameras and light sensing, scientists have recently focused on light detection techniques employed by animals such as fly's compound eye system. This innovation involves engineering the compound eye elements such as artificial ommatidium. Engineering conducted on the artificial ommatidium, similar to insect's compound eyes, consists of a refractive polymer micro-lens, a polymer cone for light-guiding, and collecting light by a self-aligned waveguide with a small angular [1, 2]. The main appealing features of compound eyes are because of their wide fields of view, high sensitivity to motion, and infinite depth of field [3]. More importantly, the optical performance of natural compound eyes has been analyzed exhaustively with respect to their resolution and sensitivity. It has been lately reported that hemispherical detector geometry, found in many other biological systems [4], enables to

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