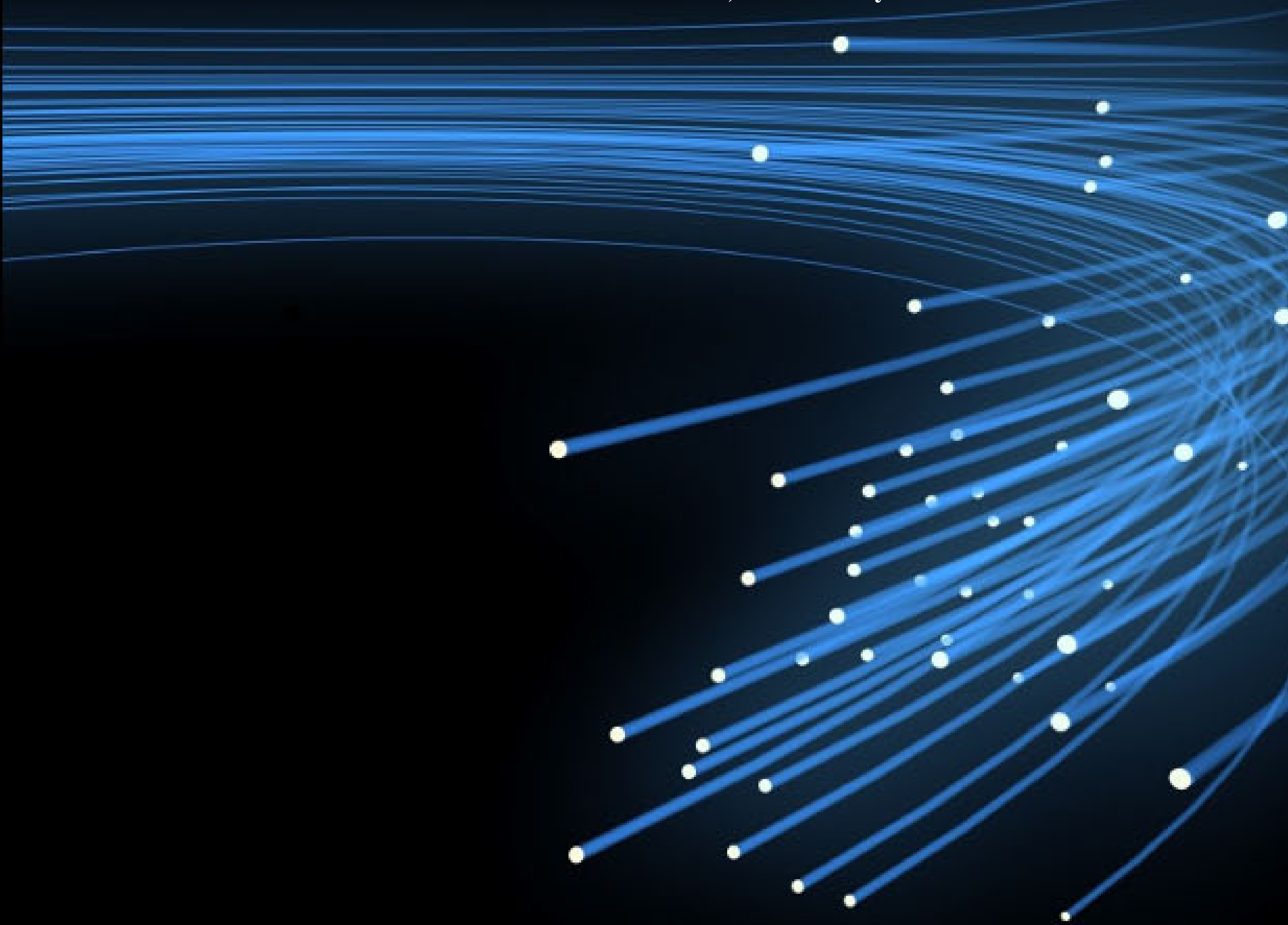
META'14 - Singapore

The 5th International Conference on Metamaterials, Photonic Crystals and Plasmonics



Program

May 20 – 23, 2014
Singapore

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Eric Plum, Jun-Yu Ou, Joao Valente, Pablo Cencillo, Nikolay Zheludev

Reconfigurable photonic metamaterials provide a flexible platform for thermo-optical, electro-optical, magneto-optical and all-optical modulation of metamaterial properties. We provide an overview from fundamental physics to practical metadevices for high-contrast light modulation.

15:15 : Invited talk
An investigation of the plasmonic effect of a single Au nanoparticle inside a dielectric microsphere
Song Sun, Lin Wu, Ping Bai

We perform a fundamental research on the plasmonic effect of a single Au nanoparticle (NP) inside a dielectric microsphere. The diameter of the microsphere d is comparable with or larger than the incident wavelength. The simulations show that the resonance wavelength of absorption cross-section (CS) always varies around 550 nm, depending on the diameter d of the microsphere. More interestingly, the location of the Au NP inside the microsphere greatly affects the absorption CS.

14:15 - 15:30 — MAS EC1

Session 4A28

Plasmonics and Nanophotonics XIII

Chaired by: Polina Kapitanova

14:15 : Probing confined phonon modes in individual CdSe nanoplatelets using surface-enhanced Raman scattering
Daniel O. Sigle, James T. Hugall, Jeremy J. Baumberg

The phonon modes of individual ultrathin cadmium selenide nanoplatelets are investigated using surface-enhanced Raman scattering in a tightly-confined plasmonic geometry. The SERS spectra, taken on single nanoplatelets sandwiched between a gold nanoparticle and a gold surface, reveal a phonon doublet arising from oscillations perpendicular to and within the platelet plane. The resulting strong electric field enhancements and the field vector reorientation within such nanometre-sized plasmonic gaps reveal otherwise hidden information about vibrational properties of ultrathin materials.

14:30 : Near-field enhancement in crescent shaped arrays
Thomas Siegfried, Shourya Dutta-Gupta, Yasin Ekinci, Olivier Martin, Hans Sigg

We present the versatile use of crescent arrays to obtain strong and homogeneous near-field enhancement over large areas. The fabrication is based on angular evaporation adding sharp metal edges and sub-10 nm gap features onto resist arrays. Such arrays support either Fano resonances or gap plasmons and show opposing near-field dependency with the gap size, as will be discussed in detail. Finally, applications will be presented evolving from crescent arrays such as radiance sensing and surface enhanced Raman scattering.

14:45 : Effective model for plasmonic coupling
Meng Qiu, Bin Xi, Shiyi Xiao, Hao Xu, Lei Zhou

We rigorously derived an effective model for plasmoniccouplings between nanoparticles. After justifying itsvalidity by full-wave simulations, we discussed aninteresting application of the effective model.

15:00 : Fano- and Lorentz-like resonances in plasmonic nanorods
Niels Verellen, Fernando Lopez-Tejeira, Ramon Paniagua-Dominguez, Dries Vercruysse, Denitza Denkova, Liesbet Lagae, Pol Van Dorpe, Victor Moshchalkov, Jose Sanchez-Gil

We present the experimental observation of spectral lines of distinctly different shapes in the optical extinction

Fano- and Lorentz-like Resonances in Plasmonic Nanorods

Niels Verellen[1,2], Fernando López-Tejeira[3], Ramón Paniagua-Domínguez[4], Dries Vercruysse[2,1], Denitza Denkova[1], Liesbet Lagae[2,1], Pol Van Dorpe[2,1], Victor V. Moshchalkov[1], and José A. Sánchez-Gil[4]

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Abstract

We present the experimental observation of spectral lines of distinctly different shapes in the optical extinction cross-section of metallic nanorod antennas. Surface plasmon resonances of odd mode parity present Fano interference in the scattering cross-section resulting in asymmetric spectral lines. Contrarily, modes with even parity appear as symmetric Lorentzian lines. Finite element simulations are used to verify the experimental results. The emergence of either constructive or destructive mode interference is explained with a semi-analytical 1D line current model. This simple model directly explains the mode-parity dependence of the Fano-like interference. Plasmonic nanorods are widely used as half-wave optical dipole antennas. Our findings offer a perspective and theoretical framework for operating these antennas at higher order modes.

1. Introduction

Metallic nanorods are widely used as generic plasmonic dipole antennas operating at optical and near-infrared frequencies, forming an analogue to classical half-wave dipole antennas. The fundamental dipole and higher order antenna modes have been extensively studied experimentally using optical spectroscopy and a broad range of mapping techniques. Likewise, theoretical investigations have elucidated the antenna modes' scaling properties, their dependence on the shape, size, and dielectric environment by using a variety of methods. Despite this large interest in nanorods, only very few theoretical reports address the scattering behavior with a focus on the spectral line shape [1-3].

2. Fano- and Lorentz-like Resonances

Plasmon resonance, as a wave phenomenon, is expected to present interference characteristics. For localized surface plasmon resonances, interference of spectrally overlapping and coupled modes is well recognized to affect the scattering behavior of the nanostructure under investigation [4, 5]. In particular, the interference of a broad background continuum state with spectrally sharp higher order resonances can lead to a spectral response with asymmetric Fano-like line shapes in a variety of nanoparticle configurations. Only recently, it was indicated that Fano resonances may appear for individual nanorods provided that interacting modes overlap in both spatial and frequency domains [1, 2]. Interestingly, the narrow asymmetrical line shape of a nanorod's Fano interference is, for example, more favorable for label-free biosensing than broader Lorentzian resonances [3].

In our present work [6], we study, both theoretically and experimentally, the spectral line shapes of nanorod antennas in detail, using extinction spectroscopy and finite element simulations. When a nanorod is illuminated with light that is polarized along its long axis, charge density waves at the surface of the metal are excited, which can form standing wave-like Fabry-Pérot resonances. The resonance mode index *l* is defined as the number of half plasmon wavelengths $\lambda_p / 2$ that fit the antenna cavity at resonance and coincides with the number of charge nodes in the corresponding charge density distribution. These longitudinal antenna modes can be separated in two categories based on the mirror symmetry of their respective charge density: modes of odd parity have an antisymmetric distribution consisting of an odd number of charge nodes *l*, while even parity modes are symmetric in their charge distribution and have an even number of charge nodes. As we will show, a distinct spectral behavior is found for even and odd parity modes. First of all, the mode parity strongly determines its coupling to light. For example, even modes will not couple to a p-polarized plane wave that impinges perpendicular to the nanorod's long axis. Hence, oblique incidence is required to excite modes with even parity. It will further be demonstrated that not only the coupling efficiency to plane waves strongly depends on the mode parity, but also the mode's spectral line shape. We will show that odd modes present asymmetric line shapes characteristic for Fano interference, while symmetric Lorentzian resonances appear for even modes. By a detailed analysis of calculated absorption and scattering cross-sections, destructive and constructive mode interference in nanorod antennas is revealed. The resulting Fano resonance line shapes are experimentally observed for first, third and fifth order antenna modes and are in excellent agreement with simulations for different rod lengths. We also present a semi-analytical model based on a one dimensional wire that reproduces the observed line shapes and gives an intuitive understanding of the underlying interference mechanisms.

Acknowledgements

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