O 49: Symposium Quantum Plasmonics (SYQP, jointly with HL, TT)

Time: Wednesday 15:00–18:05 Location: H1

Invited Talk O 49.1 Wed 15:00 H1

Quantum plasmonics and applications in light harvesting — •Peter Nordlander — Department of Physics, Rice University, Houston TX 77251, USA

Quantum effects can have a pronounced influence on the on the optical properties of strongly coupled nanoparticles.[1] For closely spaced metallic nanoparticles, electron transfer and nonlocal screening can drastically reduce the electric field enhancements across the gap and result in a Charge Transfer Plasmon (CTP) where an oscillatory electric tunneling current flows between the particles,[2] and strongly nonlinear effects can be induced.[3] The energy of the CTP is found to depend strongly on the electronic structure of the junction and the presence of molecules inside the gap.[4] For the coupled plasmonic-excitonic system where hybrid plexciton states are formed,[5] quantum effects can strongly modify the optical spectrum and a induce highly nonlinear optical response. Another plasmonic quantum mechanical effect is the nonradiative decay of plasmons into hot electron-hole pairs which can induce chemical reactions on the surface of the nanostructure [6] or be harvested directly in photodetector or photovoltaic geometries.[7]

References [1] J. Zuloaga et al., ACS Nano 4(2010)5269 [2] R. Esteban et al., Nat. Comm. 3(2012)825 [3] C. Marinica et al., Nano Lett. 12(2012)1333 [4] P. Song et al., Phys. Rev. B 86(2012)121410 [5] A. Manjavacas et al., Nano Lett. 11(2011)2318; ACS Nano 6(2012)1724 [6] S. Mukherjee et al., Nano Lett. 13(2013)nl303940z [7] M. W. Knight et al., Science 332(2011)702; Z.Y. Fang et al., Nano Lett. 12(2012)3808

Invited Talk O 49.2 Wed 15:30 H1

Deterministic quantum plasmonics with single nanodiamonds — •Serge Huant[1], Oriane Mollet[1], Aurelien Cuche[1,2], and Aurelien Drezet[1] — [1]Institut Neel, CNRS and Univ. Joseph Fourier, BP 166, 38042 Grenoble, France — [2]CEMES, CNRS, BP 94347, 31055 Toulouse, France

Using an all-optical scheme, we can attach a single nanodiamond (ND) hosting a few nitrogen-vacancy (NV) color centers onto fiber tips for near-field scanning optical microscopy (NSOM). Illuminating the grafted ND with the substrate fiber and using the fluorescence generated by the ND as source of light achieves a genuine quantum scanning optical microscopy that operates at room temperature thanks to the exceptional photostability of the NVs. In addition, we have found that the ND-based active tip is capable of launching surface-plasmon-polaritons (SPPs) into gold films. Since the ND is a quantum source of light, a limited number of single plasmons are created, depending on the actual NV occupancy. A critical prerequisite for using these SPPs in future quantum protocols is that their propagation does not destroy their quantum coherence.

In this talk, we will review our demonstration of quantum SPP launching with a ND-based active tip. Then we will demonstrate that the quantum character of the light emanating from the ND is preserved by the plasmon mediation along the gold film. Our findings open the way to a deterministic quantum plasmonics, where a well-controlled number of quantum SPPs is launched at any freely chosen position in a plasmonic receptacle.

Invited Talk O 49.3 Wed 16:00 H1

Optically-active hybrid nanostructures: Exciton-plasmon interaction, Fano effect, and plasmonic chirality — •Alexander Govorov — Ohio University, Athens, OH, USA

Excitons and plasmons in nanocrystals strongly interact via Coulomb and electromagnetic fields and this interaction leads to characteristic interference effects which can be observed in optical spectra. An interaction between a discrete state of exciton and a continuum of plasmonic states gives rise to Fano-like asymmetric resonances and anti-resonances [1,2]. These interference effects can strongly enhance visibility of relatively weak exciton signals and can be used for spectroscopy of single nanoparticles and molecules. If a system includes chiral elements (chiral molecules or nanocrystals), the exciton-plasmon interaction is able to alter and enhance circular dichroism (CD) of chiral components [3,4]. Recent experiments on molecule-nanocrystal and multi-nanocrystal complexes have confirmed our predictions [4]. Potential applications of dynamic hybrid nanostructures include sensors and new optical and plasmonic materials.

1. W. Zhang, G. W. Bryant, A. O. Govorov, Phys. Rev. Lett. 97, 146804 (2006). 2. M. Kroner, A. O. Govorov, S. Remi, B. Biedermann, S. Seidl, A. Badolato, P. M. Petroff, W. Zhang, R. Barbour, B. D. Gerardot, R. J. Warburton, and K. Karrai, Nature 451, 311 (2008). 3. A.O. Govorov, Z. Fan, P. Hernandez, J.M. Slocik, R.R. Naik, Nano Letters 10, 1374 (2010). 4. A. Kuzyk, R. Schreiber, Z. Fan, G. Pardatscher, E.-M. Roller, A. Högele, F.C. Simmel, A. O. Govorov, T. Liedl, Nature, 483, 311 (2012).

Coffee break

Invited Talk O 49.4 Wed 17:00 H1

Quantum nano-optics: Interaction of metallic nano-particles with quantum emitters — •Salvatore Savasta — Università di Messina, I-98166 Messina, Italy

Metallic nanoparticles and nanostructures are able to focus the electromagnetic field on sizes considerably smaller than a wavelength. This ability is due to the existence of collective electronic excitations on the surface of metal particles called plasmons. In this way, it is possible to increase the optical density of states as well as with the microcavities but with much more compact structures [1].

We discuss the quantum optical properties of hybrid artificial molecules composed of an individual quantum emitter and a metallic nanoparticle. The coupling between the two systems can give rise to a Fano interference effect which strongly influences the quantum statistical properties of the scattered photons [2]. Laser cooling the center-of-mass motion of nano-systems that exhibit Fano resonances is also discussed[3].

We also show, by accurate scattering calculations, that a system constituted by a single quantum emitter placed in the gap between two metallic nanoparticles [4]. Metallic-nanoparticles coupled to many quantum emitters can also achieve the ultrastrong coupling regime [5].

[1] S. A. Maier, Plasmonics: Fundamentals and Applications (Springer, New York, 2007). [2] A. Ridolfo *et al.*, Phys. Rev. Lett. **105**, 263601 (2010). [3] A. Ridolfo *et al.*, Phys, Rev, Lett. **106**, 013601 (2011). [4] S. Savasta *et al.*, ACS Nano **4**, 6369 (2010). [5] A. Ridolfo *et al.*, **109**, 193602 (2012).

Invited Talk O 49.5 Wed 17:30 H1

Non-dipolar & magnetic interactions with optical antennas — Alberto Curto[1], Martin Kuttge[1], Marta Castro-López[1], Ion Hancu[1], Tim Taminiau[2], and •Niek van Hulst[1,3] — [1]ICFO - The Institute of Photonic Sciences, Castelldefels, Barcelona — [2]Kavli Institute of Nanoscience Delft, the Netherlands — [3]ICREA - Barcelona

Plasmonic antennas are ideal to manage the interaction with single photon emitters, such as quantum dots or fluorescent molecules [1]. Tailoring the electromagnetic mode one can control electronic transitions rates and angular emission patterns, which is key for bright directed single photon sources [2]. Here we present three different examples of hybrid emitter-antenna coupled systems where electric dipole, quadrupole or magnetic dipole moments are dominant. Experimental angular radiation patterns show striking differences in the emission of resonant and non-resonant magnetic modes excited by local light sources [3]. Finally we present a magneto-electric antenna: by exploiting the interference between magnetic and electric modes we experimentally realize a compact and robust optical antenna for directed photon emission, which outperforms larger, multi-element antennas in both bandwidth and directionality.

[1] AG Curto et al. Unidirectional emission of a Q-dot coupled to a nanoantenna, Science 329, 930 (2010)

[2] TH Taminiau et al. Optical nanorod antennas as cavities for dipolar emitters: sub- & super-radiant modes, NanoLett. 11, 1020 (2011)

[3] AG Curto et al. Magnetic Resonance of a Nanoslot Optical Antenna, Submitted

Concluding remarks