Plasmons in interacting arrays of metallic nanoparticles

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Due to their small sizes, metallic nanoparticles show spectacular quantum effects that are absent in the bulk. Most of these effects stem from the confinement of the electronic eigenstates in particles with nanometric sizes. The most striking evidence of the quantization of the electronic states in metallic nanoparticles is the electronic shell structure, first observed by Knight and coworkers in 1984. The resulting size effects show up in many of the physical properties of metallic clusters, e.g., in their abundance spectra, ionization potentials, and optical properties.

Once metallic nanoparticles are put close to each other such that they interact among themselves and/or with the surrounding environment, they form metamaterials with fascinating and intriguing properties that can be very different from those of the elementary constituants. In this talk, I will focus on the optical properties of such plasmonic metamaterials.

Specifically, I will show that collective plasmons in honeycomb lattices of metallic nanoparticles behave as Dirac-like massless bosonic excitations [1]. These excitations present the same properties as electrons in graphene, such as a non-trivial Berry phase and the absence of backscattering off impurities, paving the way for a fully tunable plasmonic analogue of graphene.

I will further present recent results on plasmon polaritons, i.e., plasmons coupled to light modes, in interacting cubic arrays of metallic nanoparticles [2]. In particular, I will show that the polaritonic bandgap and the resulting reflection coefficient of the metamaterial can be significantly modulated by the polarization of light. Such an anisotropic behavior in a plasmonic metamaterial is mediated by the dipolar interactions between the nanoparticles.

[1] G. Weick, C. Woollacott, W. L. Barnes, O. Hess, E. Mariani, *Dirac-like Plasmons in Honeycomb Lattices of Metallic Nanoparticles*, Phys. Rev. Lett. **110**, 106801 (2013).

[2] G. Weick, E. Mariani, *Tunable plasmon polaritons in interacting arrays of metallic nanoparticles*, in preparation.