Performance of Non-local Optics When Applied to Plasmonic Nanostructures

Lorenzo Stella[1, 2], **Pu Zhang**[3], **F. J. García Vidal**[3],
Angel Rubio[1], **and Pablo García-González**[3]

[1]Nano-Bio Spectroscopy Group, Universidad del País Vasco, San Sebastian, Spain
[2]Department of Physics, King's College London, United Kingdom
[3]Departamento de Física Teórica de la Materia Condensada
Universidad Autónoma de Madrid, Spain

Abstract— The resonant interaction of light with metallic nanostructures is dominated by the appearance of surface plasmons. As a result, the induced electromagnetic near-field can be concentrated and enhanced in regions that are much smaller than the wave length of the incident field. This is the basis of a number of present and prosprective applications in the emerging field of nanoplasmonics. Therefore, there is a clear need for accurate theoretical tools able to predict optical properties of complex nanoplasmonic devices.

The main characteristics of a plasmon (frequency and lifetime) depend very sensitively on a delicate interplay between the geometrical details and the optical properties of a given nanostructure. Thus, time-dependent density functional theory (TDDFT) emerges as the method of choice to perform a full quantum description of collective excitations in metals. However, the range of application of TDDFT is limited by the size of the system under study. Then, simplified tools such a non-local optics based on the hydrodynamic approximation emerge as a promising alternative able to provide results with enough predictive accuracy at a much lower computational cost.

With the aim of confirming this idea, we obtain the non-local optical absorption spectra and the induced near-field in a model nanoplasmonic device (two metallic nanowires) in which there are spatial gaps between the components at nanometric and sub-nanometric scales. After a comparison against TDDFT calculations, we conclude that hydrodynamic non-local optics provides absorption spectra exhibiting qualitative agreement but not quantitative accuracy. This lack of accuracy, which is manifest even in the limit where induced electric currents are not established between the constituents of the device, is mainly due to the poor description of induced electron densities.