Final report of the exchange visit: Impact of nonlocal metal permittivity on the sensing capabilities of plasmonic resonances

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The purpose of the 9 weeks visit was establishing a scientific collaboration with the theoretical group of Prof. García-Vidal in La Universidad Autónoma de Madrid, Spain. This collaboration is set up to study theoretically how non-local effects in the dielectric function of metals affect plasmonic phenomena in nanometric structures [1]. More specifically, our attention focused on the reduction in the field enhancement capabilities of plasmonic modes in nanoparticle geometries with potential applications in the development of highly sensitive biosensing devices [2].

During the visit, two different work lines have been followed:

On the one hand, novel 3D nanoparticle geometries, such as dielectric filled crescents have been analyzed using transformation optics within the local description. This extends the work recently published in Phys. Rev. Lett. [3] and increases the range of validity of the approach.

On the other hand, nonlocal dielectric functions have been introduced in the general transformation optics framework. These have implemented in the case of a pair of touching nanowires, whose transformed counterpart is a metal-insulator-metal structure [4]. The impact of nonlocal effects in the absorption cross section and field enhancement capabilities of the system has been studied using an analytical transformation optics approach. The results obtained are in agreement with previous theoretical predictions in simpler geometries such as a single freestanding cylinder [5].

At the moment, a numerical approach using the so-called Finite Element Method is being developed to test and check the validity of the analytical results. This is the current task of the collaboration, once the scientific visit has finished. This collaboration will continue in time, exploiting the theoretical tools developed during these weeks to different nanoparticle geometries and configurations.

At least, three future publications can be expected from the work performed during the visit:

1) A. I. Fernandez-Dominguez, et al., Transformation Optics of Two Touching Nanospheres.
2) A. I. Fernandez-Dominguez et al., Light harvesting properties of dielectric loaded crescent nanoparticles.
3) A. I. Fernandez-Dominguez et al., Nonlocal effects and transformation optics for two touching nanowires.

1. V. Giannini, A. I. Fernández-Domínguez, Y. Sonnefraud, T. Roschuk, R. Fernández-García, and S. A. Maier, Small 6, 2498-2507 (2010).
2. J. A. Schuller, E. S. Barnard, W. Cai, Y. C. Jun, J. S. White, and M. l. Brongersma, Nat. Mat. 9, 193-204 (2010).
3. A. I. Fernández-Domínguez, S. A. Maier, and J. B. Pendry, Phys. Rev. Lett. 105, 266807 (2010).
4. A. Aubry, D. Lei, A. I. Fernández-Domínguez, Y. Sonnefraud, S. A. Maier, and J. B. Pendry, Nano Lett. 10, 2574-2579 (2010).
5. R. Ruppin, J. Opt. Soc. Am. B 6, 1559 (1989).