

Final report of the exchange visit: Impact of nonlocal and quantum tunnelling effects on the sensing capabilities of plasmonic resonances

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The purpose of this 5-day visit was establishing a scientific collaboration with the theoretical group of Prof. Aizpurua at the Center for Material Physics (San Sebastian, Spain). This collaboration has been set up to study theoretically how quantum effects in the optical response of metals affect plasmonic phenomena in nanometric structures. More specifically, our attention is focused on the impact that nonlocality and electron tunnelling have in nanoparticle geometries with potential applications in the development of highly sensitive biosensing devices [1].

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

On the one hand, the introduction of nonlocal dielectric functions in a general transformation optics framework has been discussed. These had been implemented in the case of a pair of touching nanowires, whose transformed counterpart is a metal-insulator-metal structure. The impact of nonlocal effects in the absorption cross section and field enhancement capabilities of plasmonic system were been studied using an analytical transformation optics approach [2].

On the other hand, a numerical approach that combines full quantum and classical optics calculations has been also treated [3]. This numerical technique takes into the occurrence of electron tunnelling effects among nanoparticles placed in close proximity.

The purpose of the collaboration is combining both techniques, and several strategies to perform this task have been proposed and discussed. This is the current task, once the scientific visit has finished. This collaboration will continue in time, exploiting the theoretical tools discussed during these days. It is expected that this work will lead to high-impact publications in the short term.

[1] A. Schuller, E. S. Barnard, W. Cai, Y. C. Jun, J. S. White, and M. I. Brongersma, *Nature Materials* 9, 193-204 (2010).

[2] A. I. Fernández-Domínguez, A. Wiener, F. J. García-Vidal, S. A. Maier, and J. B. Pendry, *Physical Review Letters* 108, 106802, 2012.

[3] R. Esteban, A. G. Borisov, P. Nordlander, and J. Aizpurua, *Nature Communications* 3, 825, 2012.