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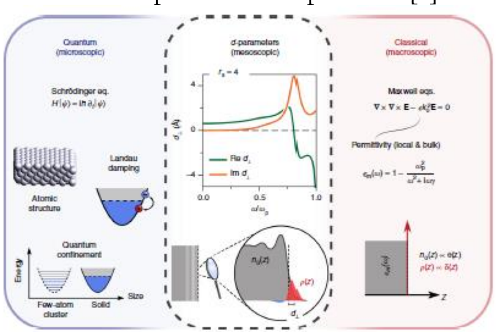
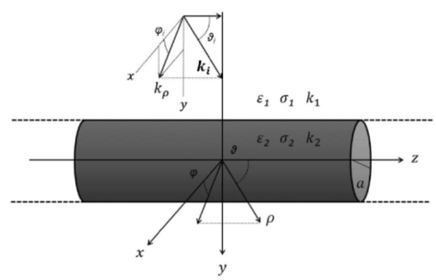
Project title: Scattering of light by metallic cylinders within a quantum-plasmonic framework	
Proposed by: Christos Tserkezis	Possible supervisor(s): Christos Tserkezis and Pedro Ninhos

PROJECT DESCRIPTION:

The interaction of light with nanoscopic matter is the subject of the rapidly evolving field of nanophotonics. Among the various new effects that can be observed when the wavelength of light is comparable to the size of the objects illuminated, collective free-electron oscillations in metallic nanoparticles, so-called plasmons, attract tremendous interest, because such structures provide unprecedented confinement and enhancement of the electromagnetic (EM) field. To push this response to its limits, ever finer plasmonic nanostructures are being designed, with their sub-nm details calling for a theoretical description that goes beyond the local response approximation (LRA) of classical electrodynamics and employs appropriate quantum-informed models, to account for effects such as screening, electron spill-out and surface-enabled Landau damping [2,3]. Among the possible approaches to tackle these issues, the one based on the Feibelman surface-response functions [4] is the most promising, because it relies on a quantum-mechanical calculation performed just once, implemented to any EM problem through mere modification of the boundary conditions. Recently, our group showed how this can be done both numerically and analytically, in the case of spherical nanoparticles [5].





The aim of this project is to expand these analytic solutions to the case of cylindrical objects, and study how spill-out affects the response of long but extremely thin metallic wires. At a first step the student will study and reproduce standard Mie theory for cylindrical objects [6]. This is an extremely efficient, accurate, and computationally cheap tool to study light scattering. Departing from LRA, the student will then familiarise with quantum-informed models for plasmonics, including hydrodynamic models for screening and damping [2], and surface-response models that get their input from quantum mechanical calculations [5]. The student will then develop his/her own computational code, in the programming language of their preference (preferably **Fortan, C++, Python or Matlab**), first to evaluate far-field scattering spectra and field distributions, in the absence or presence of quantum corrections, and subsequently to plot the near field as well. Depending on time, these solutions can be compared to those obtained with commercial software (e.g. Comsol).

[1] U. Hohenester – Nano and Quantum Optics (Springer, 2020).
[2] S. Raza et al. – J. Phys.: Condens. Matter **27**, 183204 (2015).
[3] C. Tserkezis et al. – ACS Photonics. **5**, 5017 (2018).
[4] P. J. Feibelman – Prog. Surf. Sci. **12**, 287 (1982).
[5] P. A. D. Gonçalves et al. – Nature Commun., accepted (2019).
[6] C. F. Bohren and D. R. Huffman – Absorption and Scattering of Light by Small Particles