Theoretical Study of a Cylindrical Graphene-based Localized Surface Plasmon Spaser

Leila Prélat[1] (leilaprelat@gmail.com), Mauro Cuevas[2], Nicolás Passarelli[3], Raúl Bustos Marún[4], Ricardo Depine[1]

[1] Departamento de Fisica, UBA and IFIBA, CONICET

[2] CONICET and Facultad de Ingenieria, UA

[3] Instituto de Ciencias de Materiales de Barcelona, CSIC

[4] IFEG, CONICET and Facultad de Ciencias Quimicas, UNC

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Theory

We studied localized surface plasmons (LSP) of a cylinder coated with a graphene monolayer. The H_z field is (p polarization):

$$H_z^{(1)}(\rho,\varphi) = \sum_{n=-\infty}^{\infty} c_n J_n(k_1\rho)e^{in\varphi} \qquad \rho < R$$

$$H_z^{(2)}(\rho,\varphi) = \sum_{n=-\infty}^{\infty} [A_o i^n J_n(k_2\rho) + a_n H_n^{(1)}(k_2\rho)]e^{in\varphi} \qquad \rho > R$$

Applying boundary conditions to the field H_z [1] $\rightarrow$ formulas a_n, c_n

Requiring the common denominator of the coefficients a_n and c_n to be zero, the following fully-retarded dispersion relation is obtained:

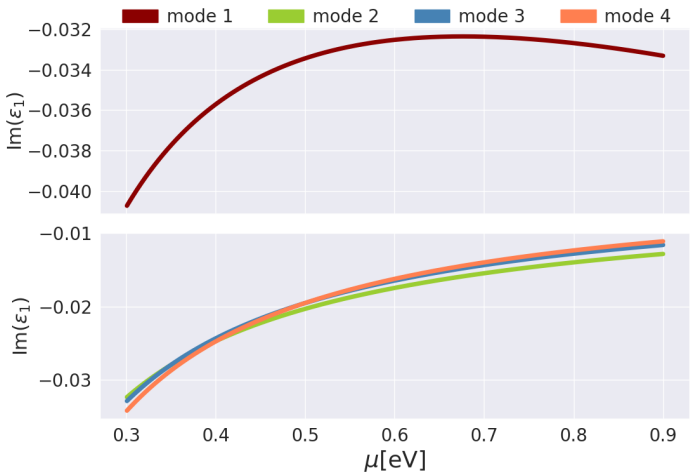
$$\mu_2 h_n - \mu_1 j_n + \frac{4\pi i}{c}\frac{\omega}{c} R\mu_1\mu_2 j_n h_n = 0$$

Results: critical values

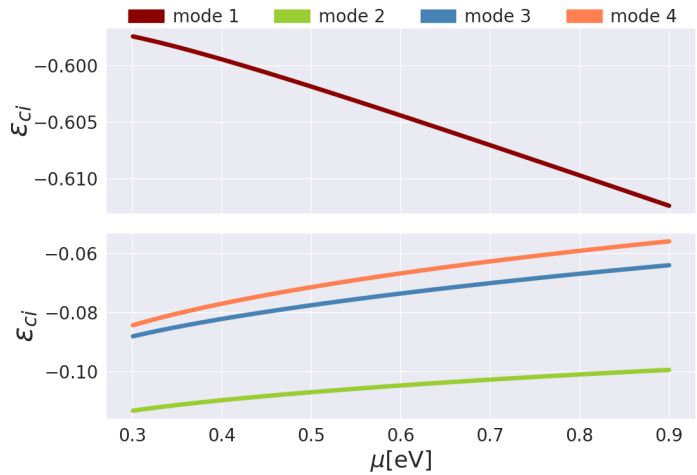
We considered two different interior media:

- Non-dispersive (dye): the ε of the medium is $\varepsilon_1 = \mathrm{Re}(\varepsilon_1) + \mathrm{i}\,\mathrm{Im}(\varepsilon_1)$
- Dispersive (mix of nanocrystal and dye): for the ε of the nanocrystal we used the DL model and the ε of the dye is $\varepsilon_{cr} + \mathrm{i}\varepsilon_{ci}$

We solved the dispersion relation and we found the optical gain vs μ_c of the graphene (tunable parameter):



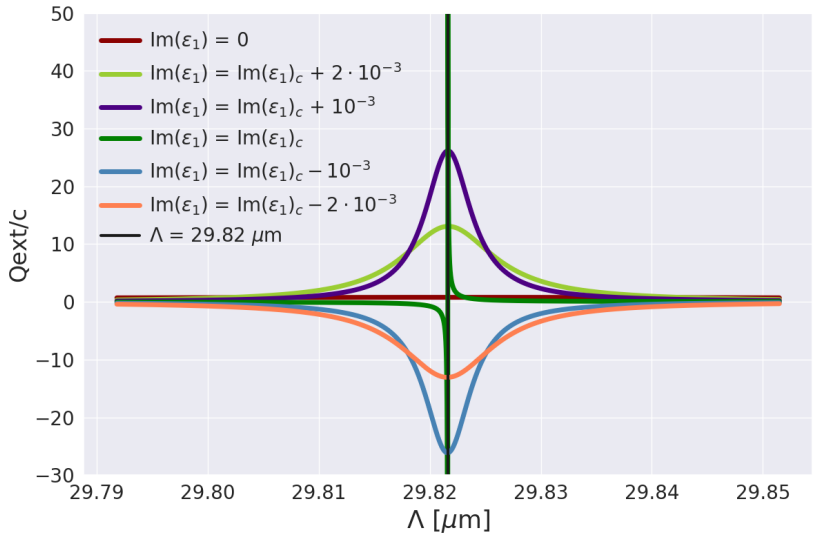
(a) Non-dispersive Dielectric medium



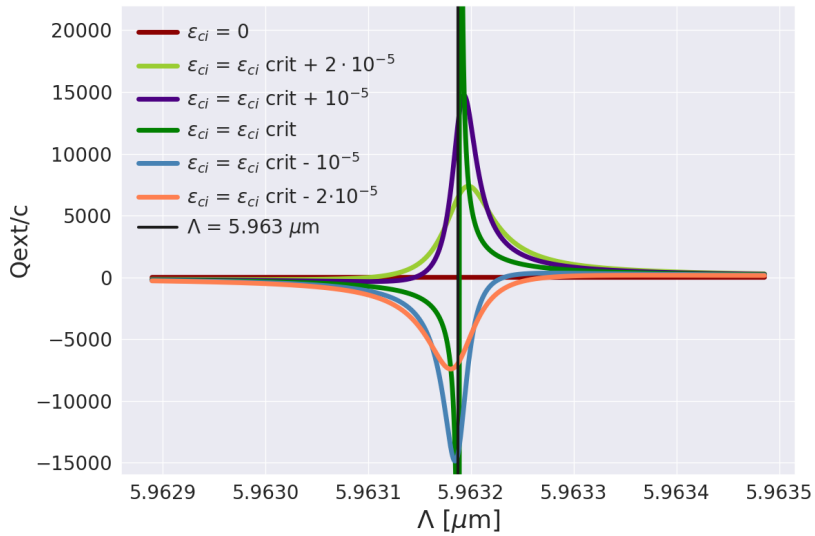
(b) Dispersive Metallic-like medium

Results: cross-sections

Extinction cross-section near the optical gains:



(a) Non-dispersive Dielectric medium



(b) Dispersive Metallic-like medium

For the critical values we observed: the extinction sign changes, the absorption minimizes and the scattering maximizes