A short guide to NPL Scattering 2D

Giuseppe Toscano

March 22, 2012

The NPL Scattering 2D has been developed as a plug-in to the RF module of COMSOL 4.2a to implement the hydrodynamic equations, that are discussed in Ref. [1]. As a reminder, I hereby report the hydrodynamic system of equations

$$\nabla \times \nabla \times \mathbf{E} = \epsilon_{bg} k_0^2 \mathbf{E} - j\omega\mu_0 \mathbf{J}, \tag{1a}$$

$$\beta^2 \nabla (\nabla \cdot \mathbf{J}) + (\omega^2 - j\omega\gamma)\mathbf{J} = -j\omega\epsilon_0 \omega_p^2 \mathbf{E}, \tag{1b}$$

which are subject to the usual Maxwell boundary conditions, and to the additional boundary condition (ABC) $\mathbf{J} \cdot \mathbf{n} = 0$ on the metallic boundaries.

The RF module automatically implements the Maxwell wave equation (1a) with the related boundary conditions, while the hydrodynamic equation (1b) has been added by using the PDE module.

The current implementation of the code allows to perform the *far-field analysis* for a cylindrical rod infinitely extended in one dimension, as reported in Refs.[1, 2].

The code is structured as follows

- Constants, parameters, and variable declaration
- Declaration of geometrical entities
- RF module
- PDE module plug-in
- Solver for single frequency analysis
- Solver for frequency sweep analysis
- Results visualization

The *Constant declaration* includes the definition of the main constants and parameters of the hydrodynamic model. The *Declaration of geometrical entities* includes the definition of the PML (Perfectly Matched Layers) domain, the metallic domain, and the surrounding dielectric domain. The *RF module* includes two types of wave equations

- Local Drude model equations (Eq. (1b) with $\beta = 0$)
- Nonlocal hydrodynamic model equations

The code is configured to perform the hydrodynamic equations analysis. However, it can perform the ordinary Drude equations analysis by simply disabling the PDE mode section (the hydrodynamic equations) and enabling the Drude equation in the RF module.

For any questions or support, feel free to contact me at `gtos@fotonik.dtu.dk`.

Have fun COMSOLing with NPL Scattering 2D!

References

[1] *Unusual resonances in nanoplasmonic structures due to nonlocal response*, S. Raza, G. Toscano, A.-P. Jauho, M. Wubs and N. A. Mortensen, Phys. Rev. B 84, 121412(R) (2011).
(`http://link.aps.org/doi/10.1103/PhysRevB.84.121412`)

[2] *Modified field enhancement and extinction by plasmonic nanowire dimers due to nonlocal response*, G. Toscano, S. Raza, A.-P. Jauho, N. A. Mortensen, and M. Wubs, Optics Express, Vol. 20, Issue 4, pp. 4176-4188 (2012).
(`http://dx.doi.org/10.1364/OE.20.004176`)