DESIGN OF A SOFTWARE TOOL FOR THE SIMULATION OF PLASMONIC PARTICLES

Deniz Eren Mol, Umut Can Tosun

Supervisor: Prof. Dr. Özlem Özgün

Electrical and Electronics Engineering, Hacettepe University

Introduction

When an incident coherent light meets a metal-dielectric boundary, at the interface the light is trapped in a nanometer region [1]. The trapped lights' strength is enhanced on the order of 30-300 at the so called ''Hot Spots''. This enhancement factor enables its use in spectroscopy [2], quantum circuits [3], waveguides [4] and many more which pave the way to terahertz level applications.

In this project we have developed a MATLAB toolbox (Figure-3) using Finite Difference Time Domain (FDTD) approach to simulate plasmonic nanoparticles. The toolbox let user define parameters such as source and geometry to observe effects in various conditions giving user freedom over choice of parameters.

Methods and FDTD formulation

A system defined by differenttial equations can be represented by difference equations to solved by numeric simulations which is used when problems' analytical solution is hard to solve.

Forward, Backward and Central difference formulas:

$$\frac{df}{dx} = \frac{f(x) - f(x - \Delta x)}{\Delta x} \qquad (1.1)$$

$$\frac{df}{dx} = \frac{f(x + \Delta x) - f(x)}{\Delta x} \qquad (1.2)$$

$$\frac{df}{dx} = \frac{f(x + \Delta x) - f(x - \Delta x)}{\Delta x} \qquad (1.3)$$

We have used central difference since it shows less error.
For the propagation of light two of the Maxwell's curl equations can be used and dicretized in this manner. While discretizing this equations Yee lattice, which is a field positioning scheme is used as shown below:

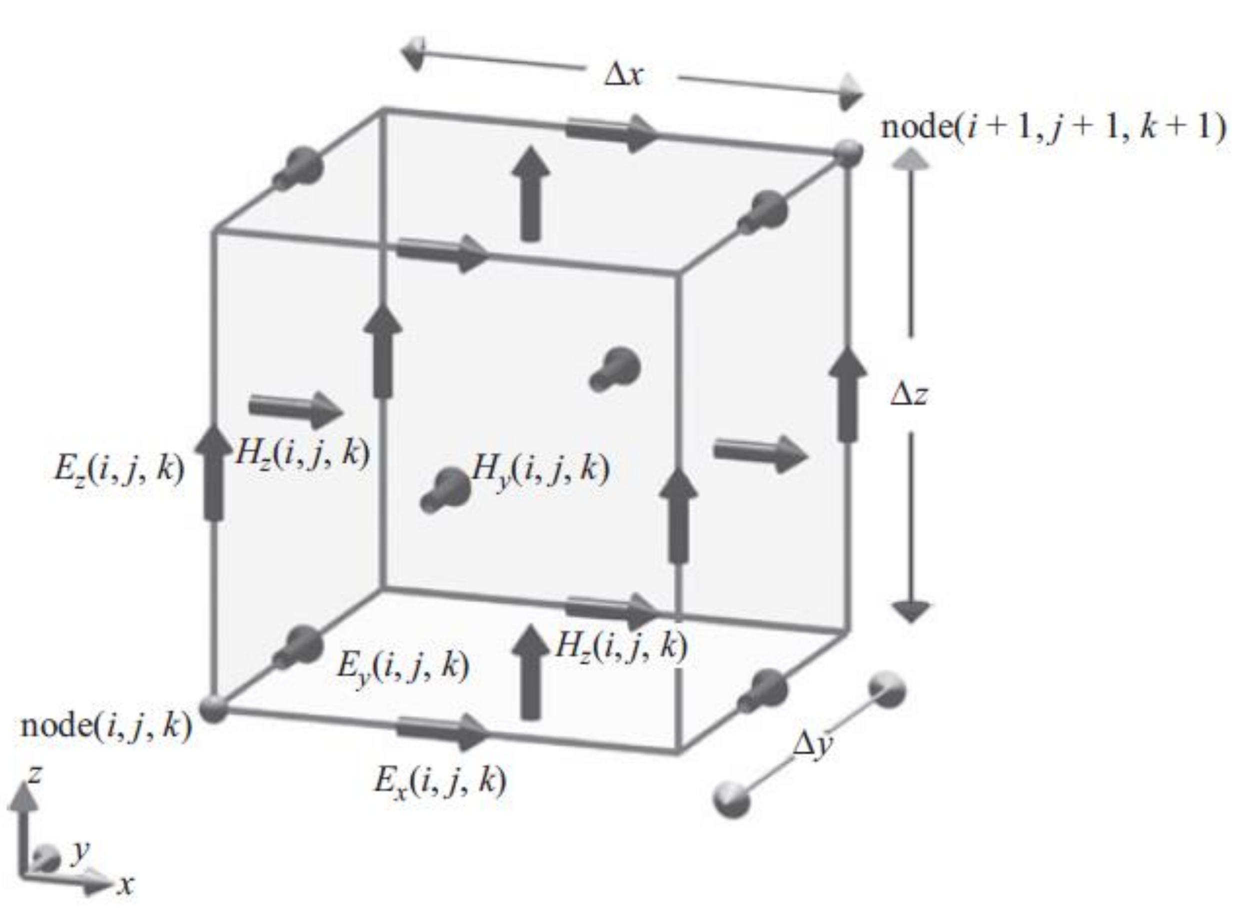

Figure-1, Yee Cel [5]

Maxwell's Curl Equations:

$$\nabla x \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\nabla x \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

Design and GUI

Discretization based on Figıure-1 and equations 1.1-1.3:

$$\frac{E_x^{n+1} - E_x^{n}}{\Delta t} = \frac{1}{\varepsilon_z}\frac{(H_z^{n+\frac{1}{2}} - H_z^{n+\frac{1}{2}})}{\Delta y} - \frac{1}{\varepsilon_z}\frac{(H_y^{n+\frac{1}{2}} - H_y^{n+\frac{1}{2}})}{\Delta z} - \frac{1}{\varepsilon_z} J_x$$

Where the superscript indicates sampling instants. The fields are sampled consecutively at time.

Proposed System For observing plasmonic particles:

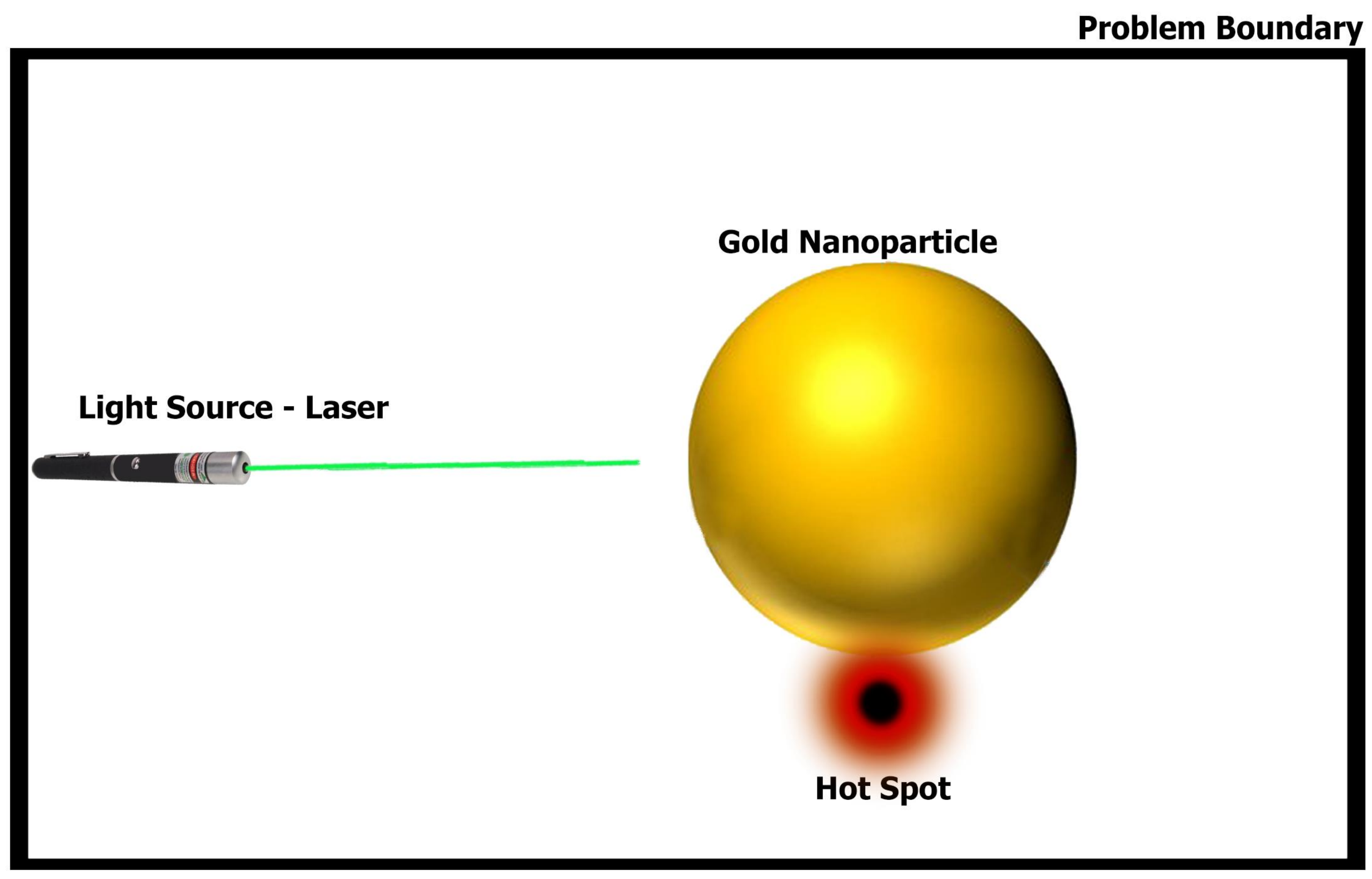

Figure-2, Plasmonic Hot Spot Creation

ADE Formula for modelling dispersive gold nanoparticles:

$$\varepsilon_r(\omega) = \varepsilon_\infty + \frac{\varepsilon_s - \varepsilon_\infty}{1 + i\,\omega\tau} + \frac{\sigma}{i\omega\varepsilon_0}$$

Results

We have developed a GUI where user can define source and geometries

Developed GUI:

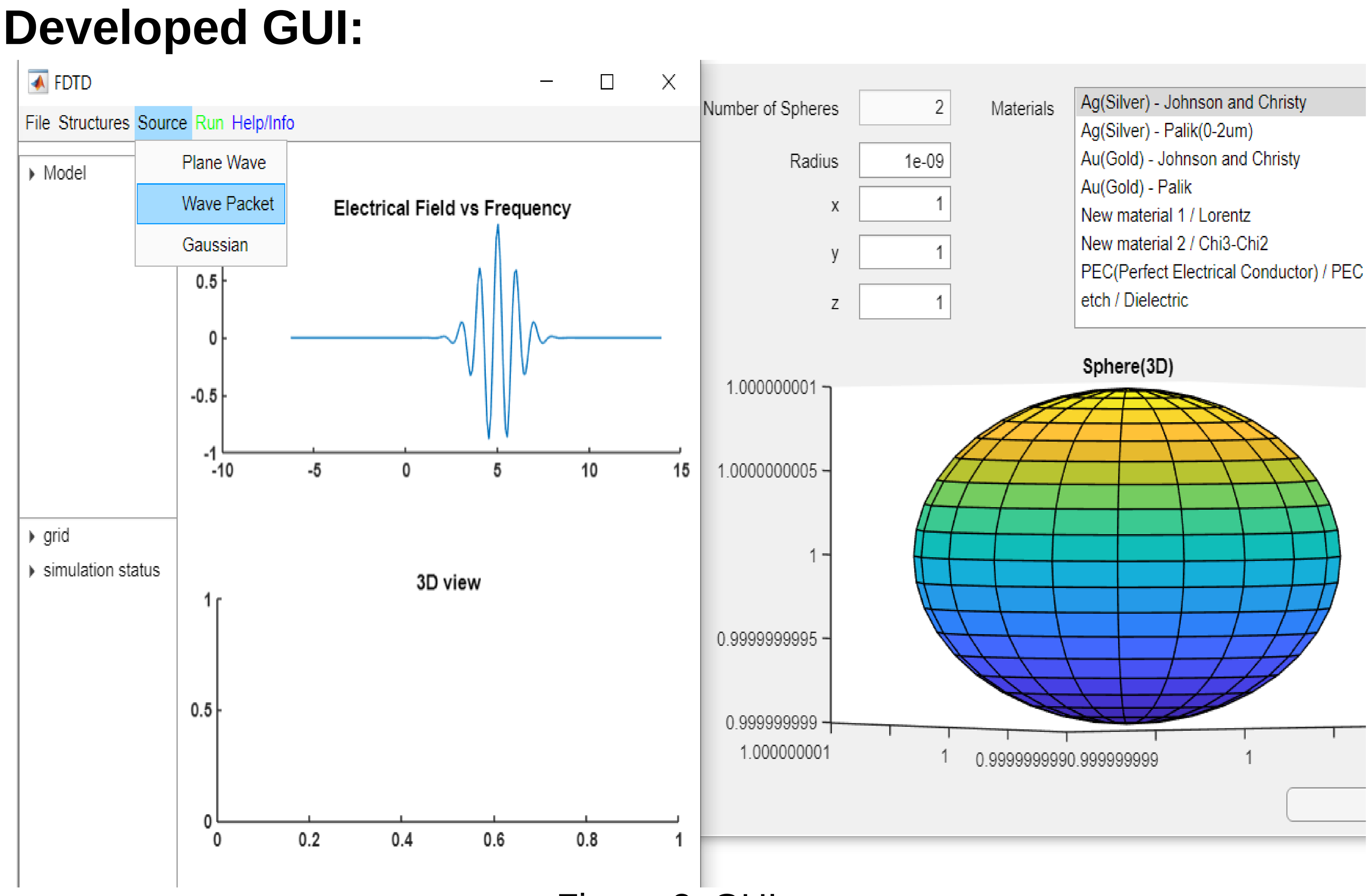

Figure-3, GUI

References and acknowledgements

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