FDTD Simulation: Plane Wave Interaction with Infinite Dielectric Cylinder

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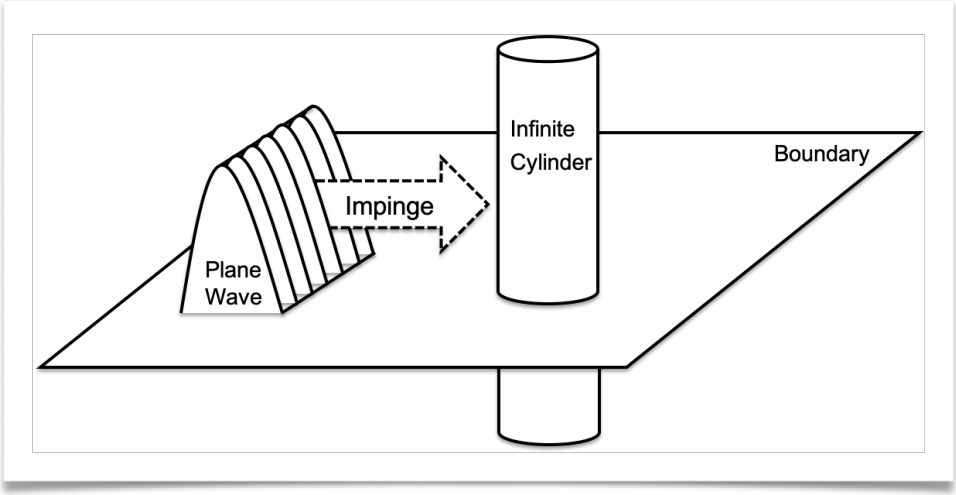
Introduction — Problem

Finite Difference Time Domain (FDTD)

- A method for solving electromagnetic computational problems
- The basis of the code is the two Maxwell curl equations in derivative form in the time domain
- The equations are expressed in a linearized form using central finite differencing
- Simulation: **A plane wave impinging on an infinite dielectric cylinder (2-Dimension)**

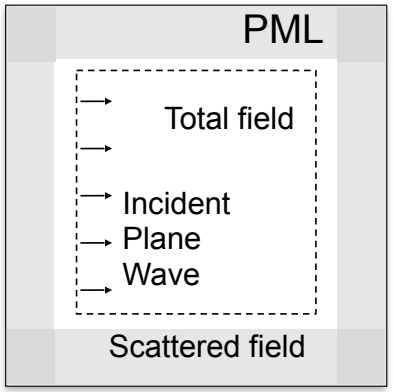


Modeling — 1st Step

Generate plane wave in free space

Point 1:

PML: Perfectly Matched Layer (Absorption Boundary Condition)



Point 2:

Scattered Field Formalism: E = E^total = E^incident + E^scattered

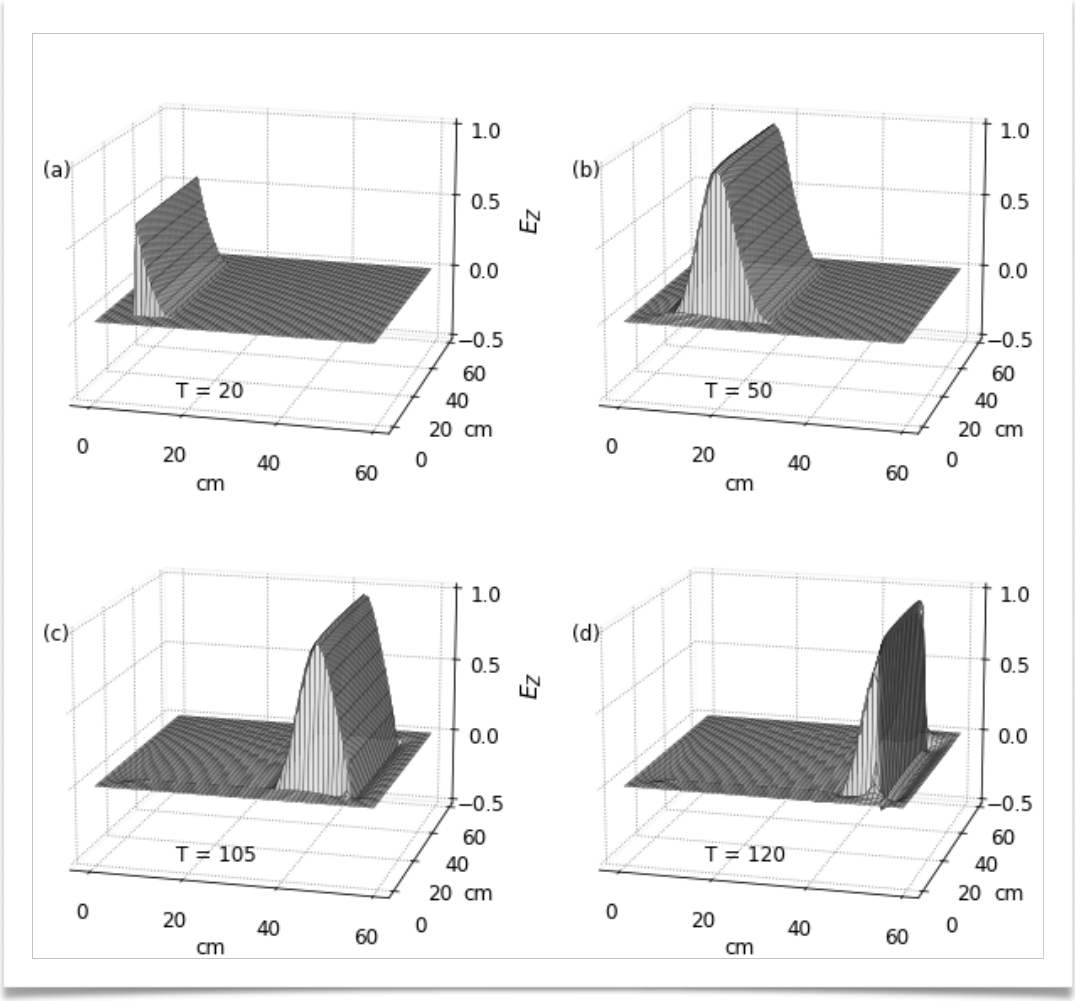
E^incident:

```
# Source
pulse = exp(-0.5 * ((t0-time_step)/spread) ** 2)
ez_inc[3] = pulse
```

E^total:

```
# Ez field
ez = gaz * dz
```

Results — Simulation 1



Simulation of a plane wave pulse propagating in free space.

The incident pulse is generated at one end and subtracted from the other end.

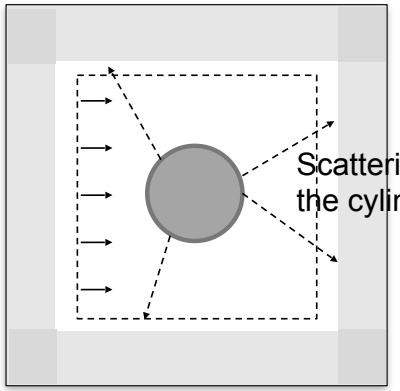
(a)T=20
(b)T=50
(c)T=105
(d)T=120

Modeling — 2nd Step

Impinge on the infinite dielectric cylinder

Cylinder:

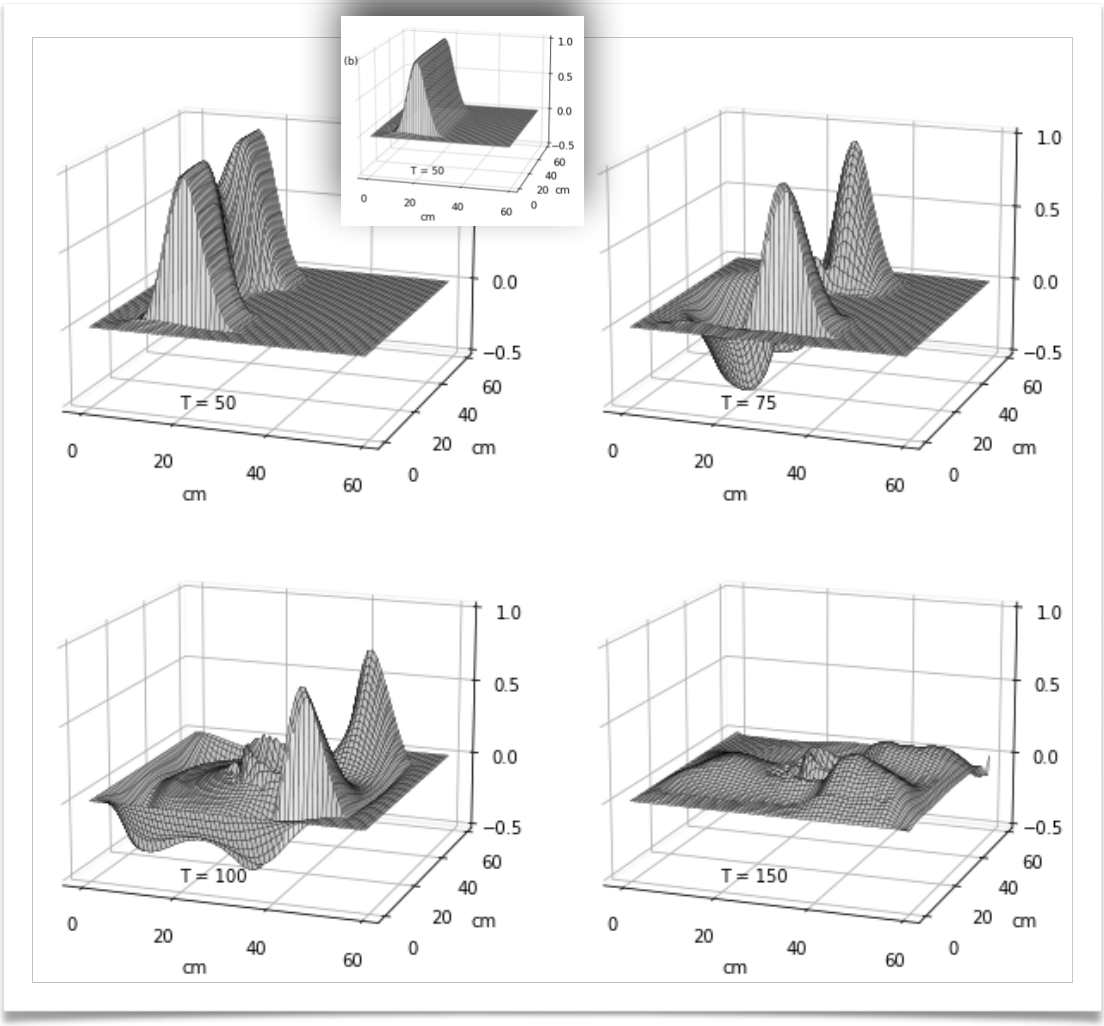
```
# Specify the dielectric cylinder
epsr = 30 # relative dielectric constant
sigma = 0.3 # conductivity
radius = 10

# Create Dielectric Profile
epsz = 8.854e-12

for j in range(ja,jb):
    for i in range(ia,ib):
        xdist = ic-i
        ydist = jc-j
        dist = sqrt(xdist ** 2 + ydist ** 2)
        if dist <= radius:
            gaz[i,j] = 1/(epsr+(sigma*dt/epsz))
            gbz[i,j] = (sigma * dt)/epsz
```



E^total:

```
# Ez field
for j in range(0,je):
    for i in range(0,ie):
        ez[i,j] = gaz[i,j] * (dz[i,j] - iz[i,j])
        iz[i,j] = iz[i,j] + gbz[i,j] * ez[i,j]
```

Results — Simulation 2



Simulation of a plane wave impinging on a dielectric cylinder.

The cylinder is 20cm in diameter and has a relative dielectric constant of 30 and a conductivity of 0.3S/m.

Reference

[1] https://qiita.com/sandshiP/items/f07f6c1443e024cb775a

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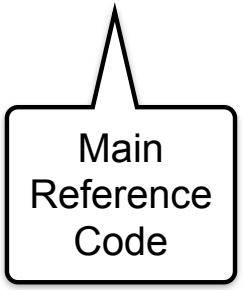
[3] K. S. Kunz, R. J. Luebbers, Finite Difference Time Domain Method for Electromagnetics (2017).

[4] D. M. Sullivan, J.E. Houle, Electromagnetic Simulation Using the FDTD Method with Python (2019).



Thank you :)