wave solver with PML

summer 2017

The actual code models the 2D EM wave assuming $\partial_z = 0$ and quasi-isotropic materials with attenuation for both E_z and $\mathbf{H}$,

$$\begin{pmatrix} \mu_y & 0 & 0 \\ 0 & \mu_x & 0 \\ 0 & 0 & \varepsilon_z \end{pmatrix} \begin{pmatrix} \dot{H}_y \\ -\dot{H}_x \\ \dot{E}_z \end{pmatrix} = \begin{pmatrix} 0 & 0 & \partial_x \\ 0 & 0 & \partial_y \\ \partial_x & \partial_y & 0 \end{pmatrix} \begin{pmatrix} H_y \\ -H_x \\ E_z \end{pmatrix} - \tag{1}$$

$$\begin{pmatrix} \sigma_y^m & 0 & 0 \\ 0 & \sigma_x^m & 0 \\ 0 & 0 & \sigma_z \end{pmatrix} \begin{pmatrix} H_y \\ -H_x \\ E_z \end{pmatrix} + \begin{pmatrix} 0 \\ 0 \\ -J_z \end{pmatrix}. \tag{2}$$

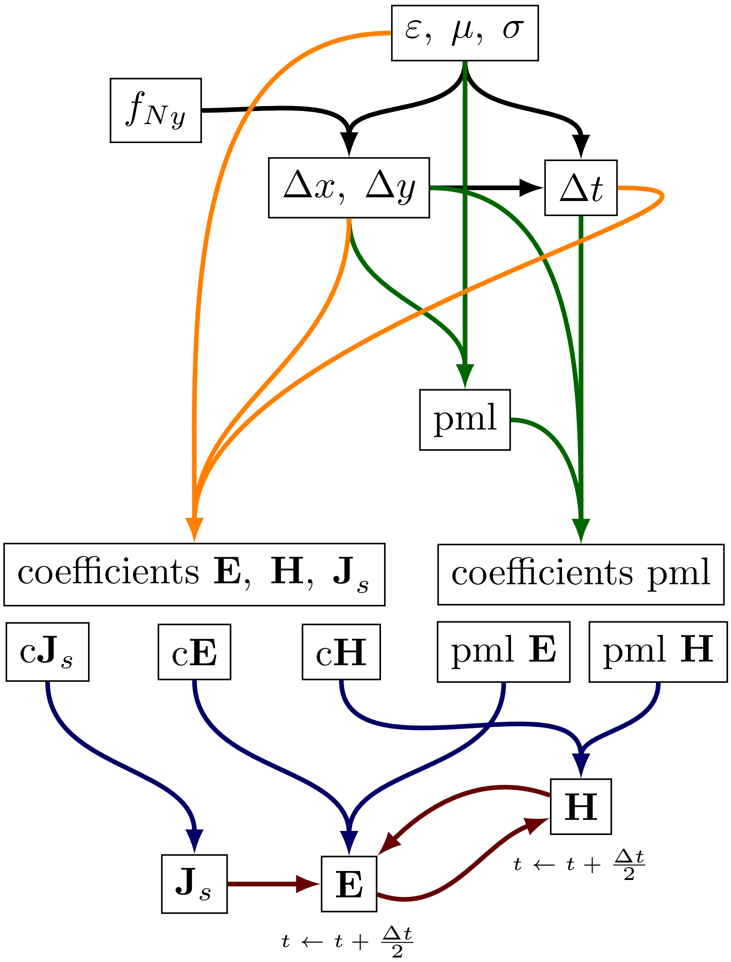

Figure 1: Main code flow.

$$c_o = \frac{1}{\sqrt{\varepsilon_o \mu_o}}$$

$$c_{min} = \frac{c_o}{\sqrt{\varepsilon_{max}}} \qquad c_{max} = \frac{c_o}{\sqrt{\varepsilon_{min}}}$$

$$\lambda_{min} = \frac{c_{min}}{f_{Ny}} \propto \Delta x \longrightarrow \Delta t = \frac{\text{cfl}}{c_{max}\sqrt{\left(\frac{1}{\Delta x}\right)^2 + \left(\frac{1}{\Delta y}\right)^2}}$$

Figure 2: Calculation of $\Delta x, \Delta y$ and Δt.

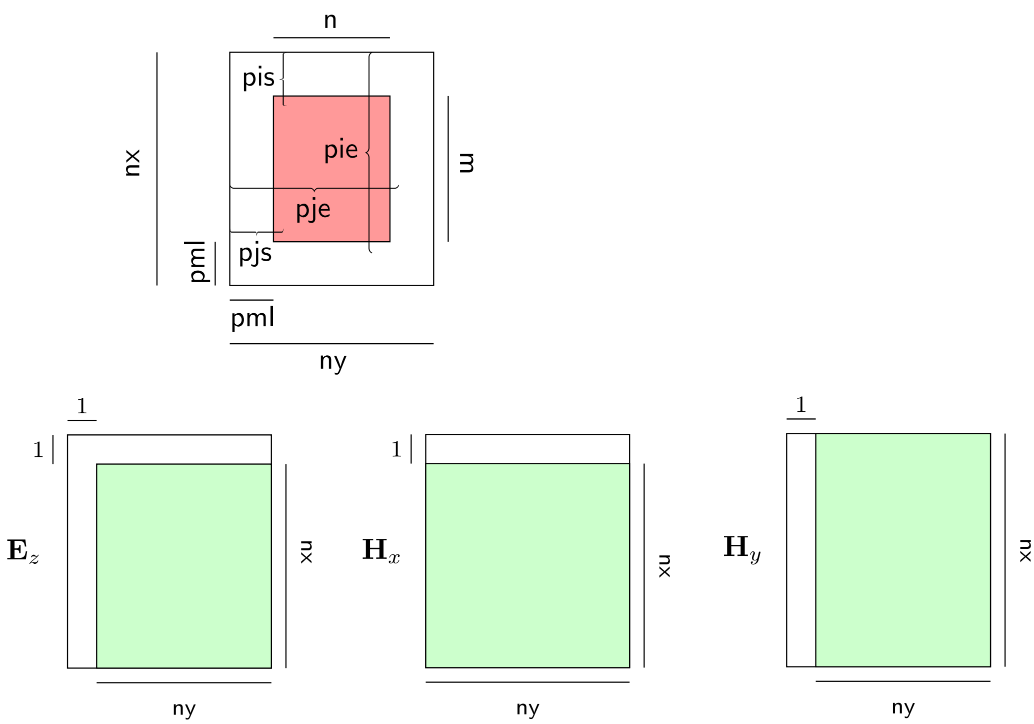

Figure 3: Grid dimensions of $\mathbf{E}_z$, $\mathbf{H}_x$, $\mathbf{H}_y$.

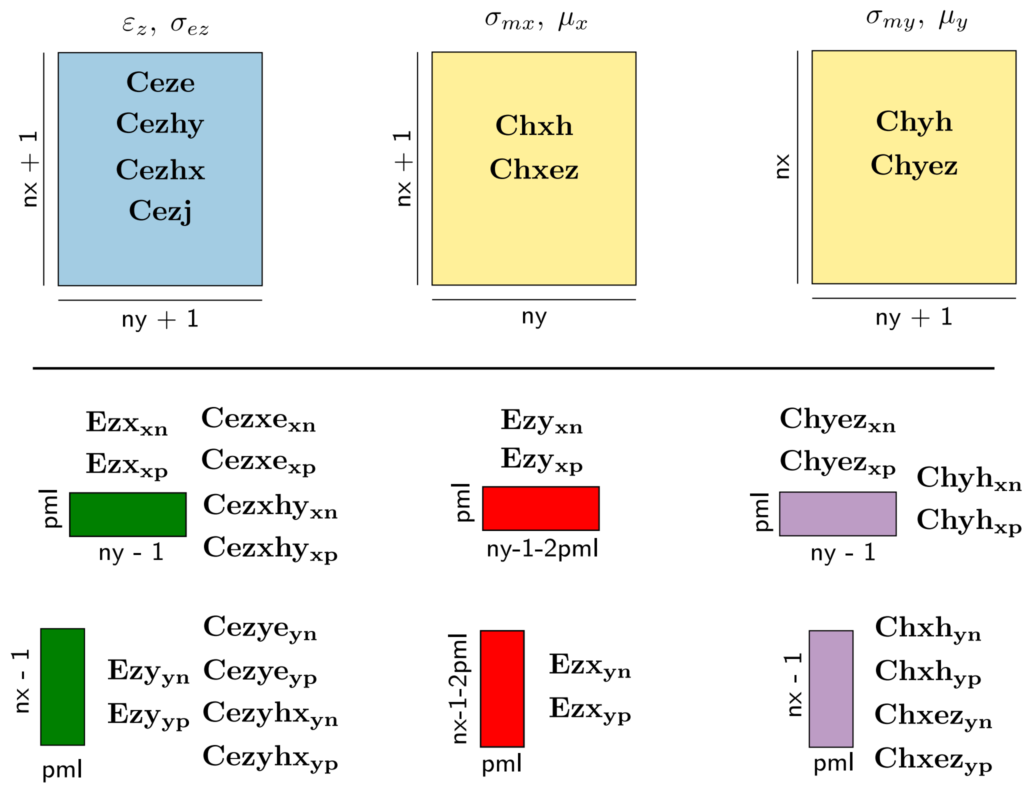

Figure 4: Coefficients of all nodes (**up**), and PML nodes (**down**).

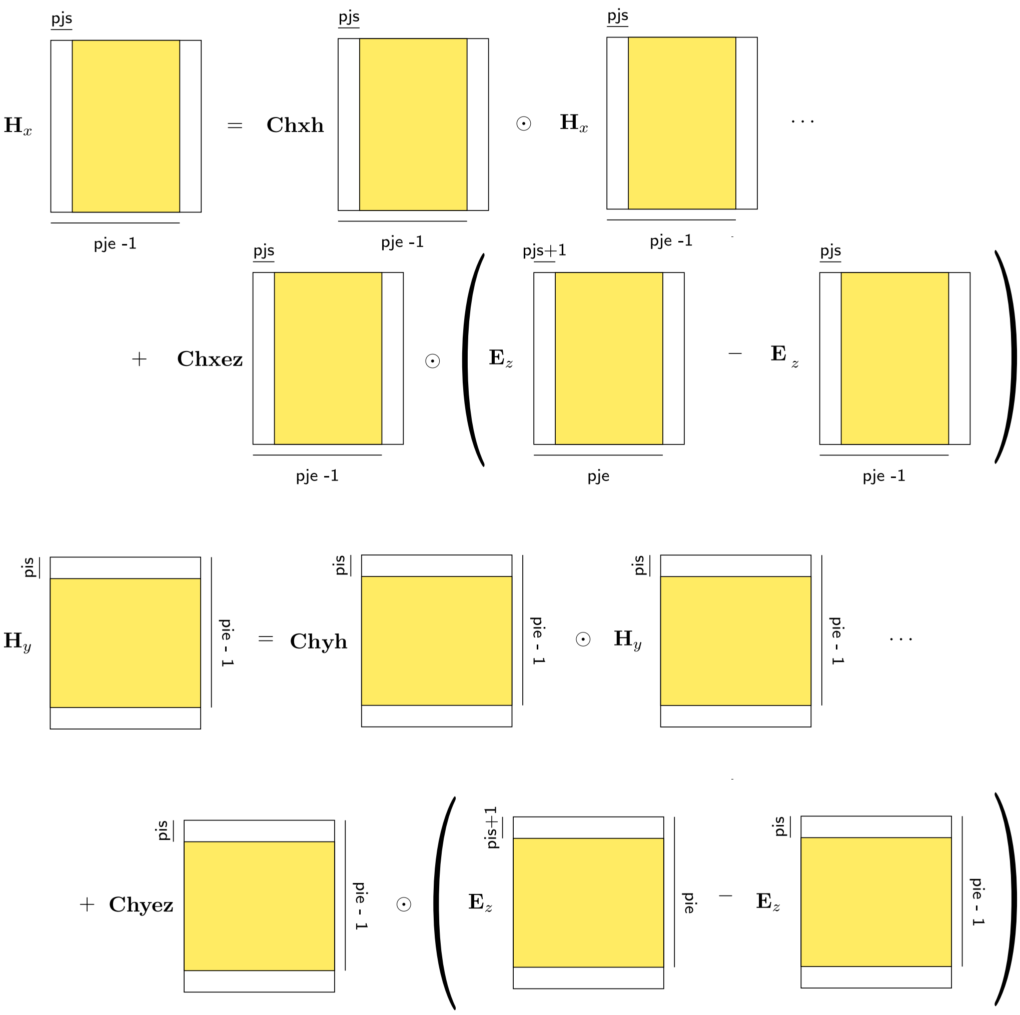

Figure 5: Update of $\mathbf{H}_x$ and $\mathbf{H}_y$. One line of nodes into PML.

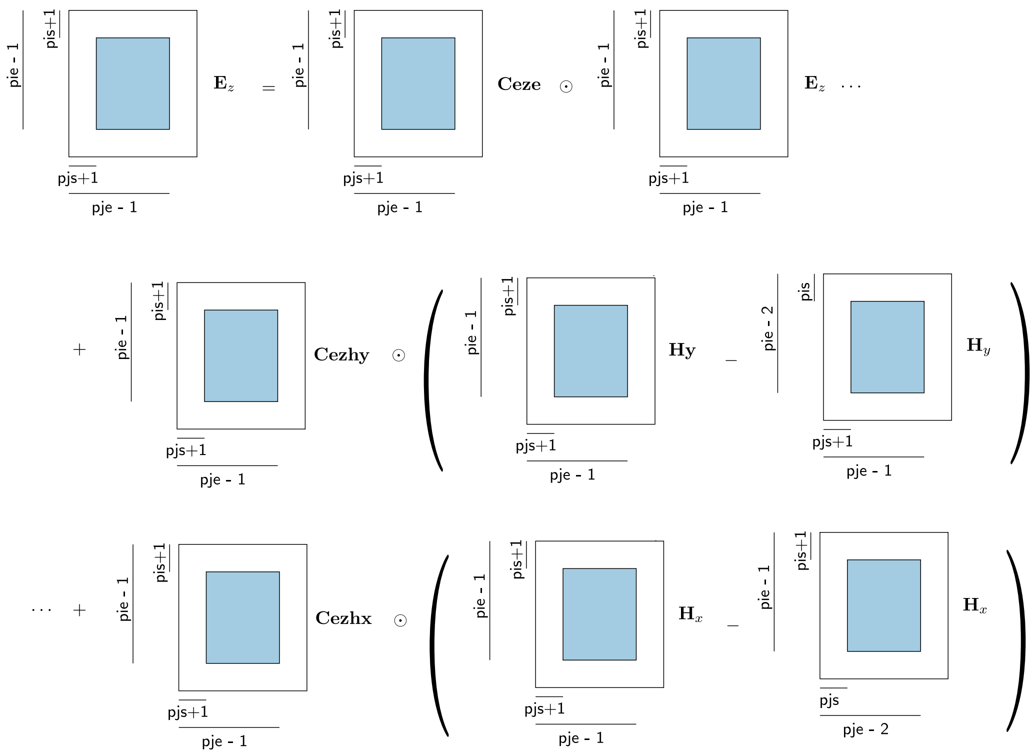

Figure 6: Update of $\mathbf{E}_z$. One line of nodes into PML.

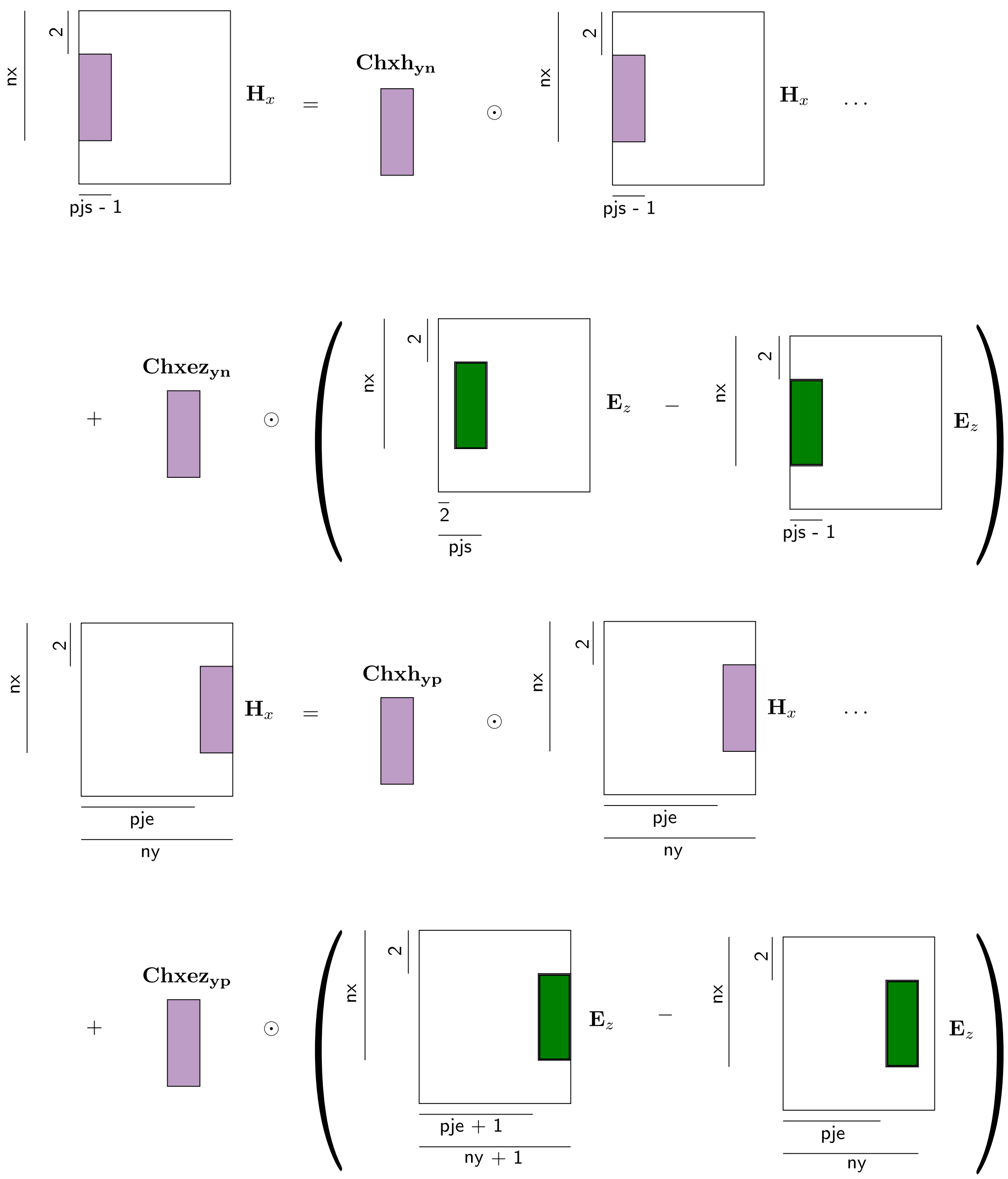

Figure 7: PML update for $\mathbf{H}_x$. PML proper.

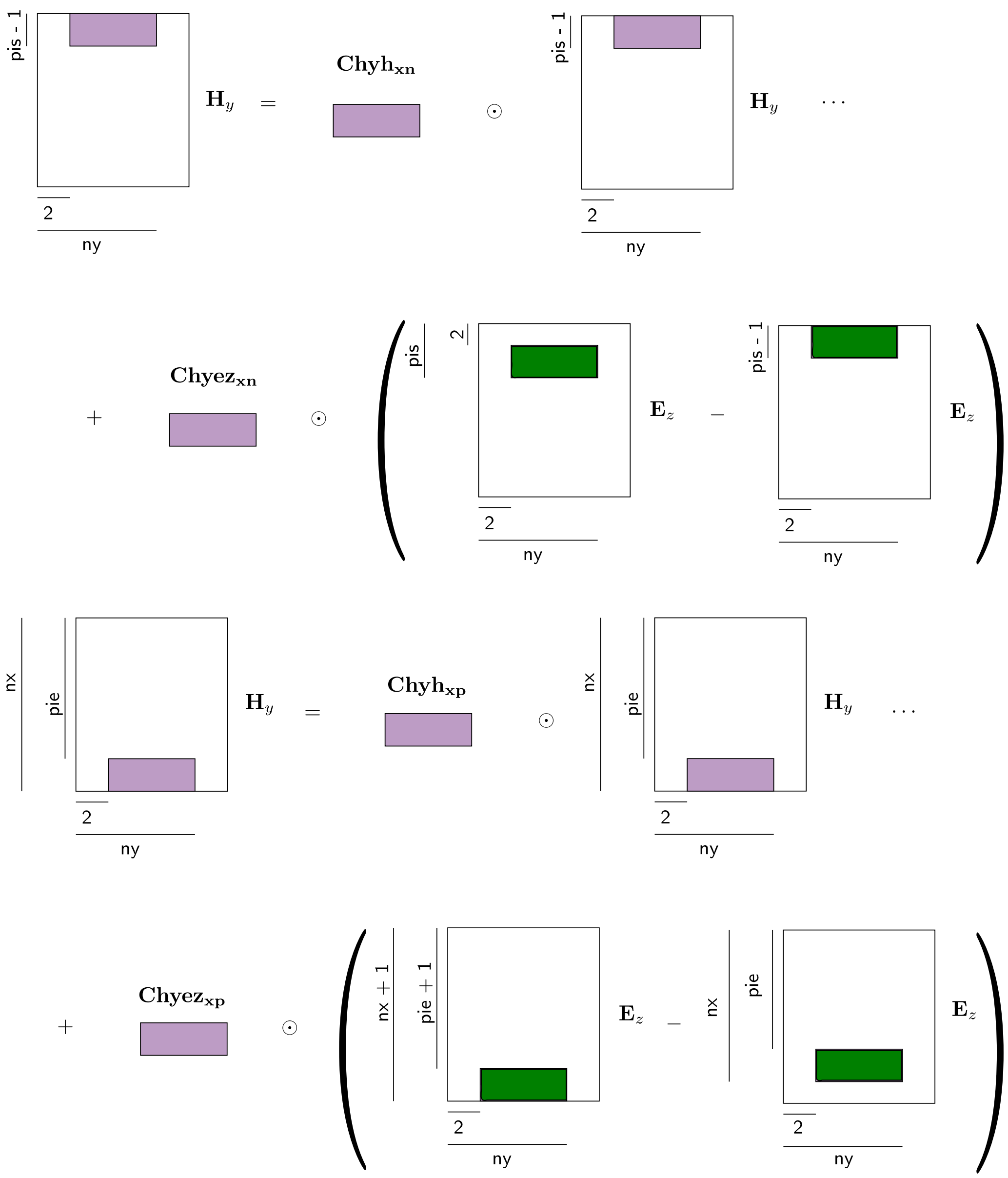

Figure 8: PML update for $\mathbf{H}_y$. PML proper.

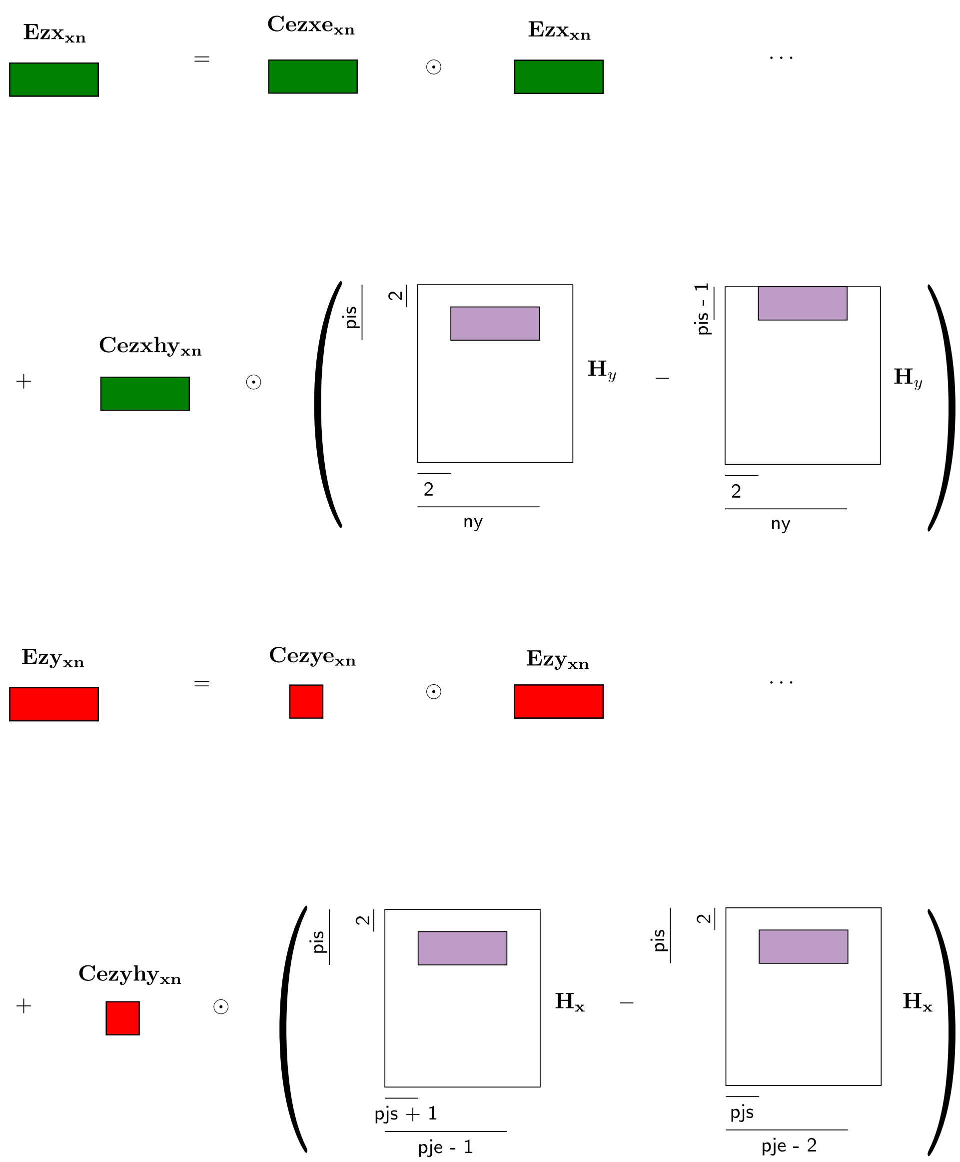

Figure 9: PML update for $\mathbf{E}_{zx}$ up. One line of nodes into inner nodes.

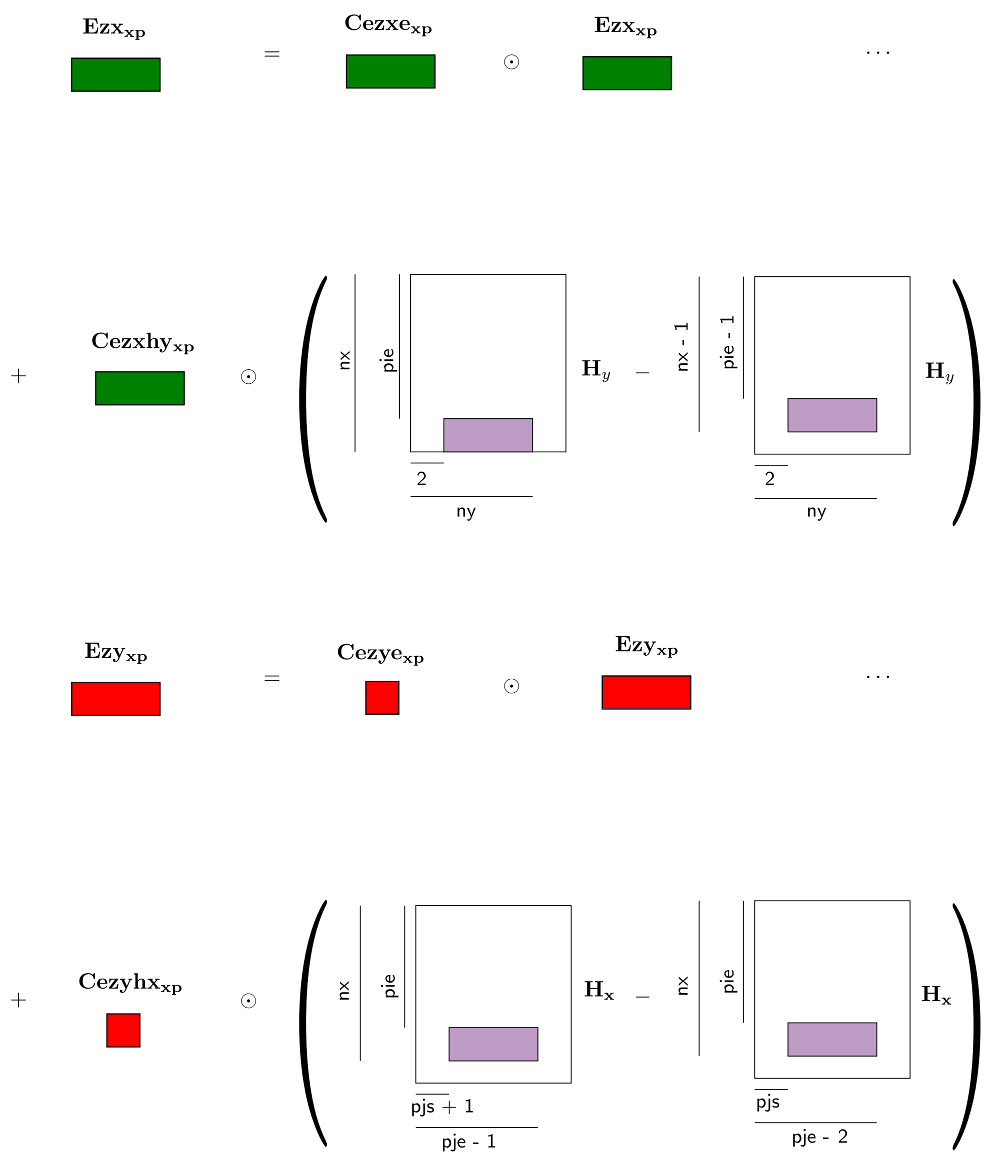

Figure 10: PML update for $\mathbf{E}_{zx}$ down. One line of nodes into inner nodes.

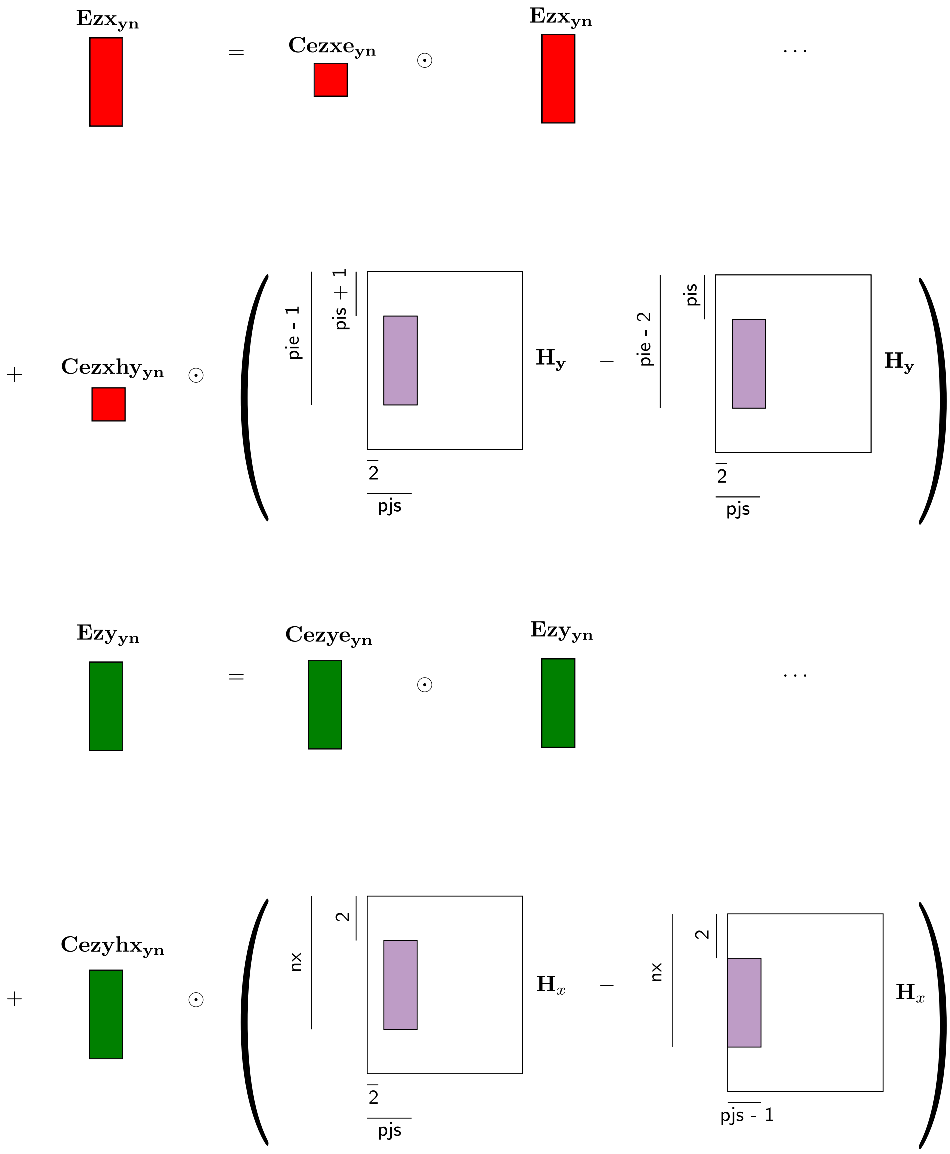

Figure 11: PML update for $\mathbf{E}_{zy}$ left. One line of nodes into inner nodes.

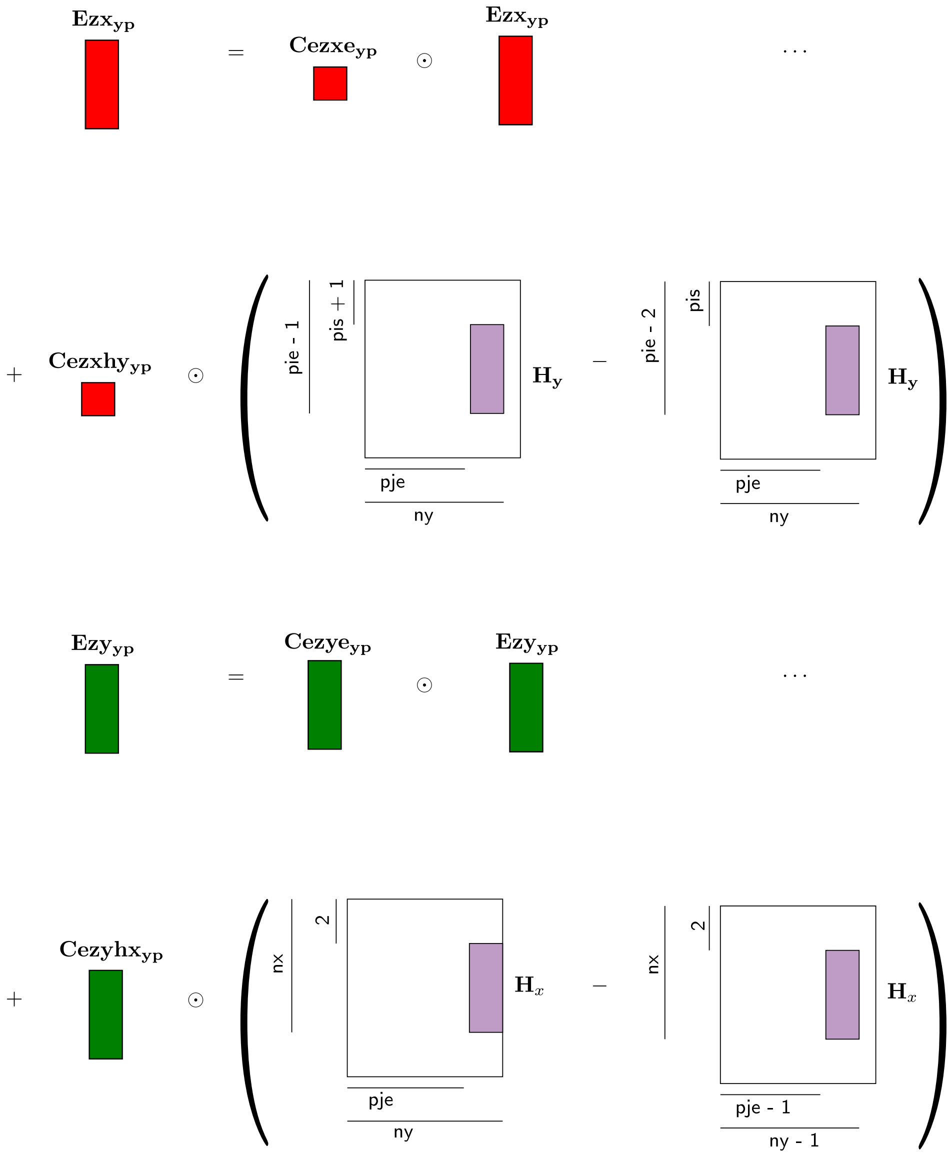

Figure 12: PML update for $\mathbf{E}_{zy}$ right. One line of nodes into inner nodes.

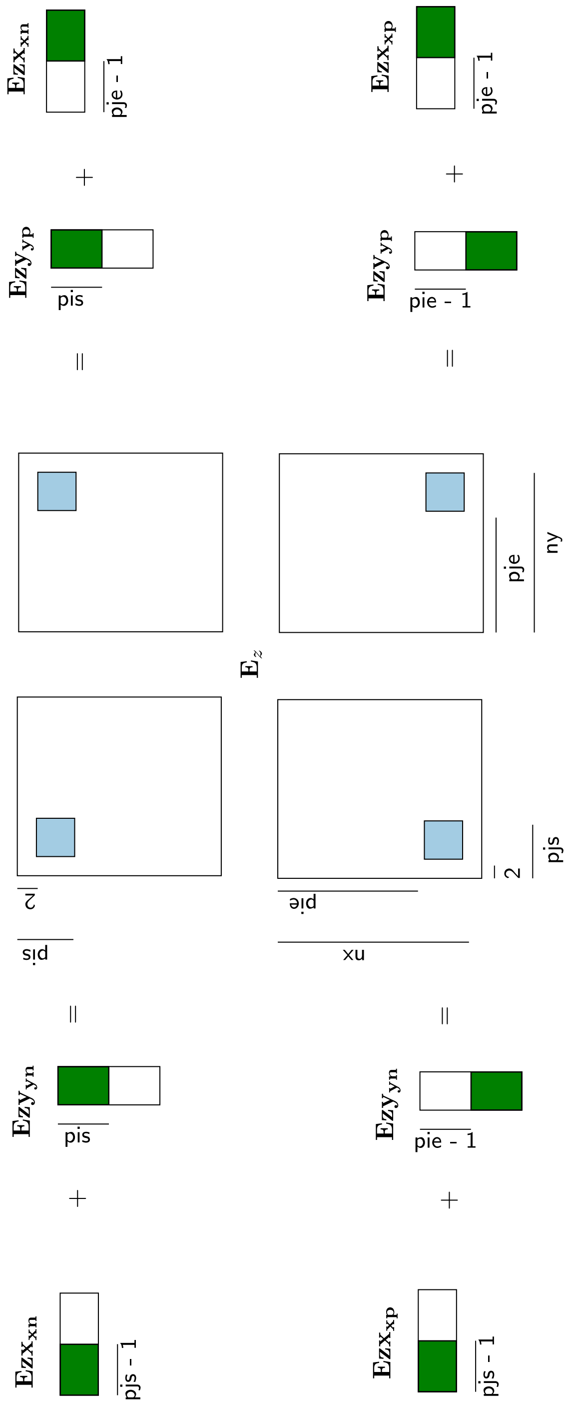

Figure 13: PML update for $\mathbf{E}_z = \mathbf{E}_{zx} + \mathbf{E}_{zy}$ corners. PML proper.

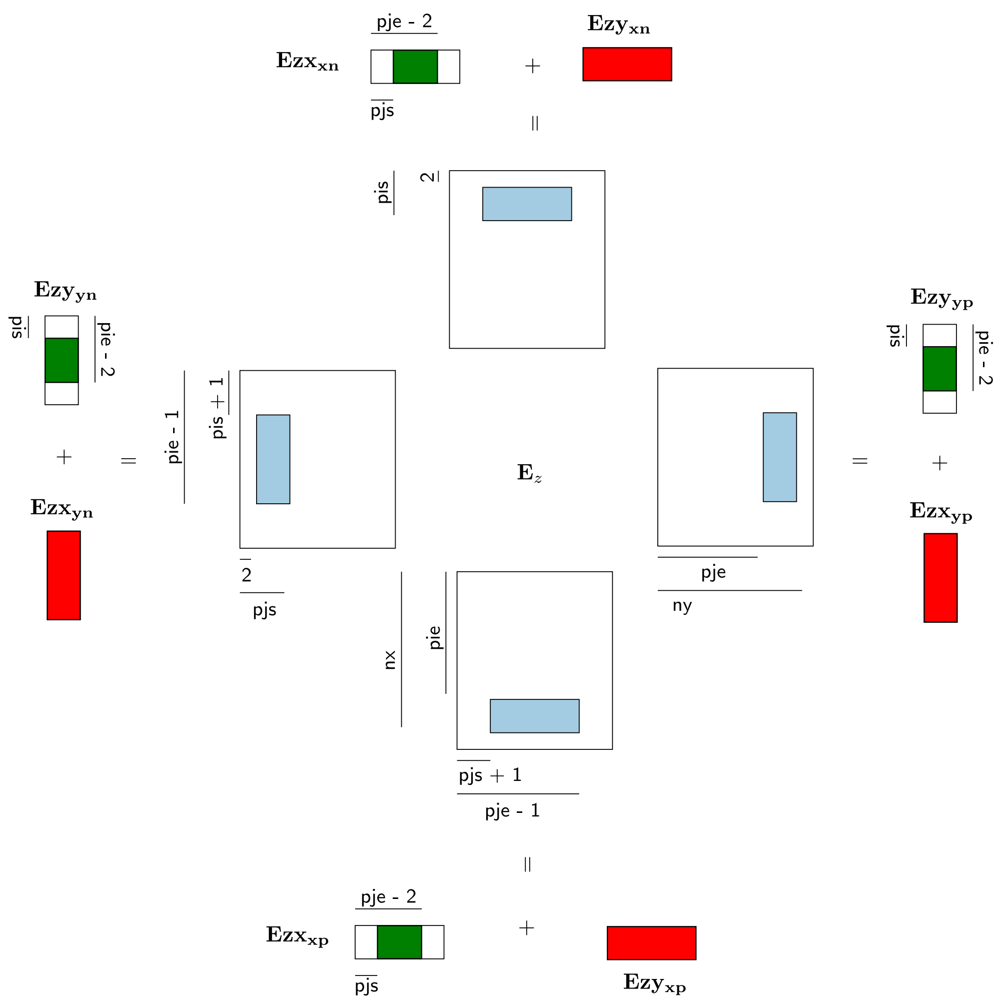

Figure 14: PML update for $\mathbf{E}_z = \mathbf{E}_{zx} + \mathbf{E}_{zy}$ sides. PML proper.