Project 12

Team member

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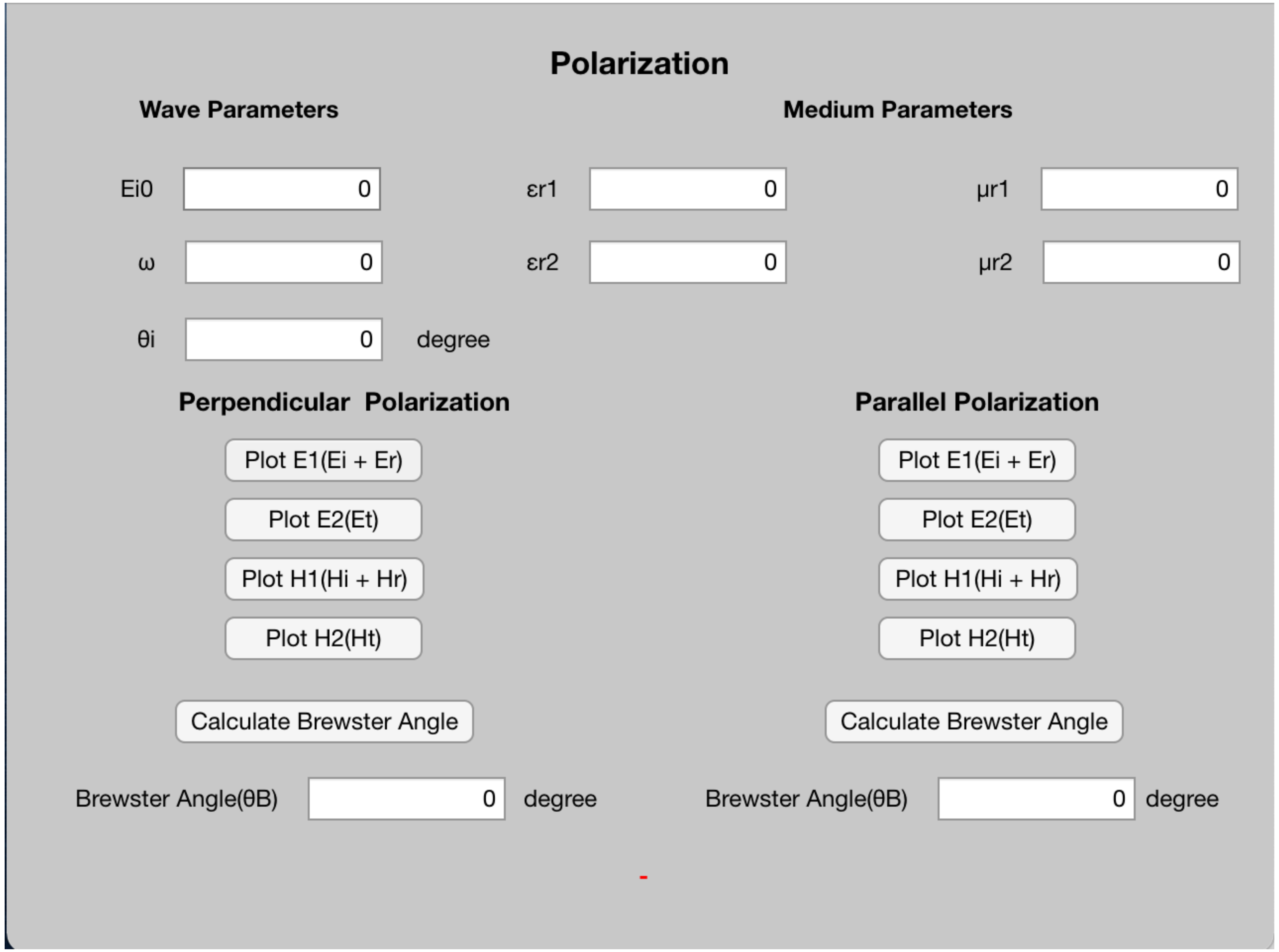
Project description

Assume a y-polarized uniform plane wave (E_i, H_i) is incident at an angle of incidence θ_i from medium 1 (ϵ_{r1}, μ_{r1}) on medium 2 (ϵ_{r2}, μ_{r2}) at x=0. Plot the instantaneous expressions of total fields E_1 (=E_i + E_r), H_1 (= H_i + H_r), E_2 (=E_t), H_2 (=H_t) of the wave in media 1 and 2, respectively. Consider both parallel and perpendicular polarizations separately. Determine the Brewster angle for different cases. The parameter values E_{i0}, ω, θ_i, ϵ_{r1}, μ_{r1}, ϵ_{r2}, μ_{r2} will be provided from user-end.

GUI Design


Polarization
Wave Parameters
Medium Parameters
Ei0
0
εr1
0
μr1
0
ω
0
εr2
0
μr2
0
θi
0
degree
Perpendicular Polarization
Parallel Polarization
Plot E1(Ei + Er)
Plot E2(Et)
Plot H1(Hi + Hr)
Plot H2(Ht)
Plot E1(Ei + Er)
Plot E2(Et)
Plot H1(Hi + Hr)
Plot H2(Ht)
Calculate Brewster Angle
Calculate Brewster Angle
Brewster Angle(θB)
0
degree
Brewster Angle(θB)
0
degree

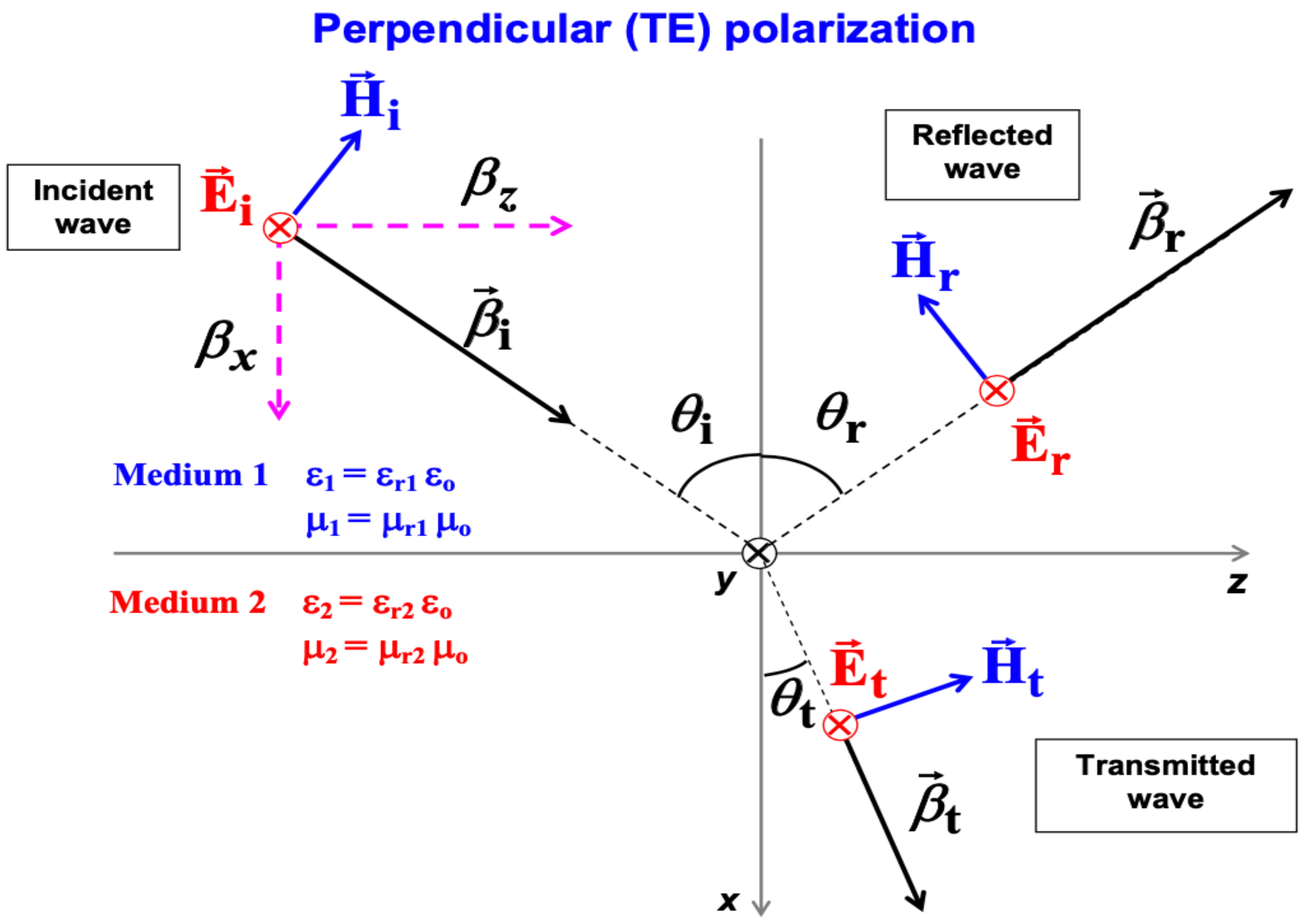
GUI Functioning

1.Parameter values $E_{i0}, \omega, \theta_i, \epsilon_{r1}, \mu_{r1}, \epsilon_{r2}, \mu_{r2}$ are provided from user end

2. Can plot incident, reflected and transmitted waves.

3. Can calculate Brewster angle for perpendicular and parallel polarization cases.

Case1: Perpendicular polarization



In case of perpendicular polarization, the electric field is perpendicular to the plane of incidence and the magnetic field is parallel to the plane of incidence.

For the above case, since the incident electric field, Ei is

$$E_i = \hat{a}_y E_{i0} e^{-j\beta_1(xcos\theta_i + zsin\theta_i)}$$

And the reflected electric field, Er is

$$E_r = \hat{a}_y \Gamma_\perp E_{i0} e^{-j\beta_1(zsin\theta_i - xcos\theta_i)}$$

Then the total electric field in medium 1, E1 will be Ei+Er

$$E_1 = E_i + E_r$$

$$E_1 = \hat{a}_y E_{i0} e^{-j\beta_1(xcos\theta_i + zsin\theta_i)} + \hat{a}_y \Gamma_\perp E_{i0} e^{-j\beta_1(zsin\theta_i - xcos\theta_i)}$$

Similarly. since the incident magnetic field, Hi is

$$H_i = (-\hat{a}_x sin\theta_i + \hat{a}_z cos\theta_i)\,.\frac{E_{i0}}{\eta_1}e^{-j\beta_1(xcos\theta_i + zsin\theta_i)}$$

And the reflected magnetic field, Hr is

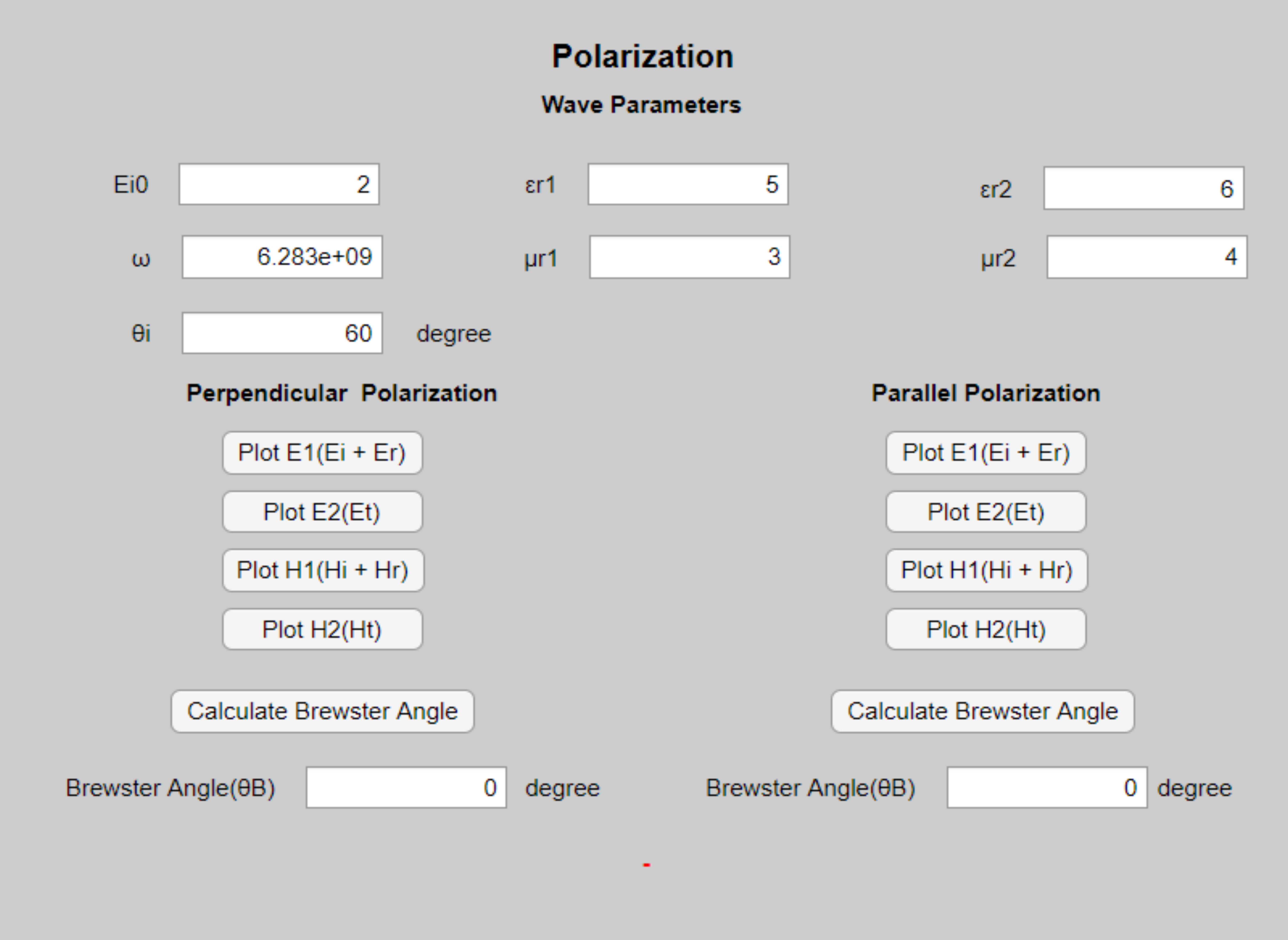
$$H_r = -(\hat{a}_x sin\theta_r + \hat{a}_z cos\theta_r)\Gamma_\perp \frac{E_{i0}}{\eta_1}e^{-j\beta_1(-xcos\theta_r + zsin\theta_r)}$$

Then the total magnetic field in medium 1, H1 will be Hi+Hr

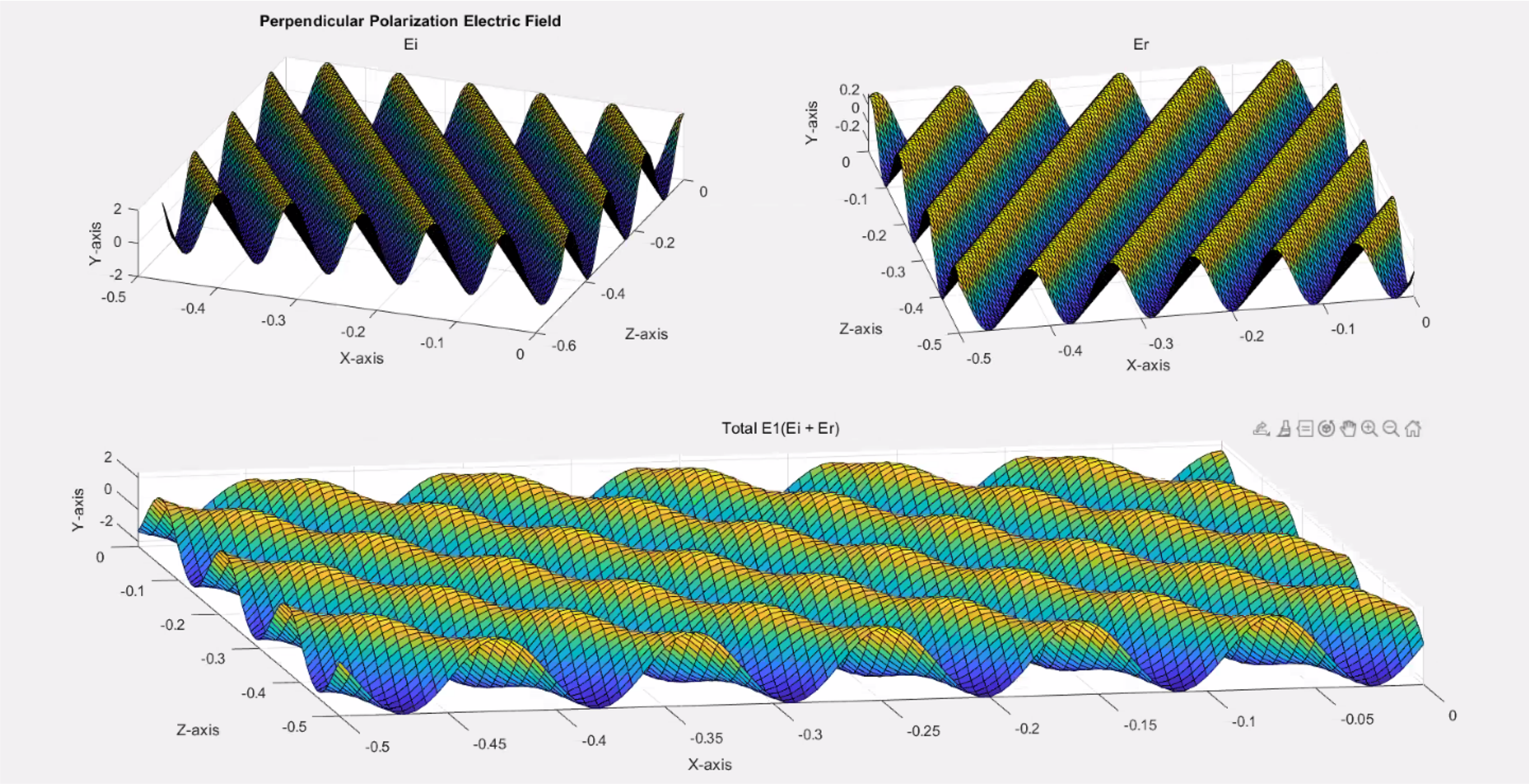
$$H_1 = H_i + H_r$$

$$H_1 = (-\hat{a}_x sin\theta_i + \hat{a}_z cos\theta_i)\,.\frac{E_{i0}}{\eta_1}e^{-j\beta_1(xcos\theta_i + zsin\theta_i)} - (\hat{a}_x sin\theta_r + \hat{a}_z cos\theta_r)\Gamma_\perp \frac{E_{i0}}{\eta_1}e^{-j\beta_1(-xcos\theta_r + zsin\theta_r)}$$

Plotting E1 and H1 in GUI

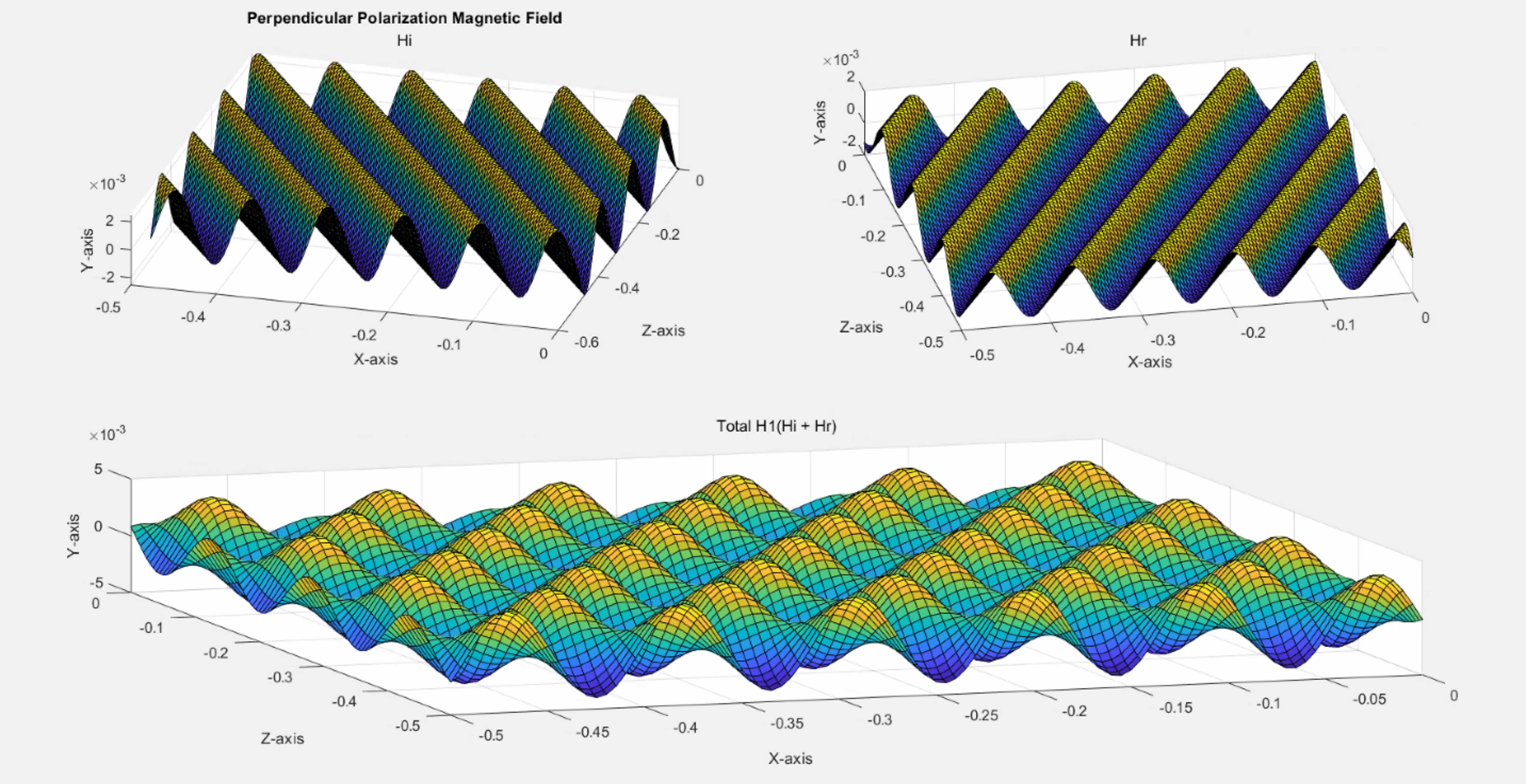


E1(Ei+Er)



Perpendicular Polarization Electric Field
Ei
Er
Y-axis
X-axis
Z-axis
Total E1(Ei + Er)

H1(Hi+Hr)


Perpendicular Polarization Magnetic Field
Hi
Hr
Total H1(Hi + Hr)
X-axis
Y-axis
Z-axis
×10-3

Now, in medium 2 the transmitted electric field, Et is

$$E_t = \hat{a}_y \tau_\perp E_{i0} e^{-j\beta_2(x cos\theta_t + z sin\theta_t)}$$

Then the total electric field in medium 2, E2 will be (E2=Et)

$$E_2 = E_t = \hat{a}_y \tau_\perp E_{i0} e^{-j\beta_2(x cos\theta_t + z sin\theta_t)}$$

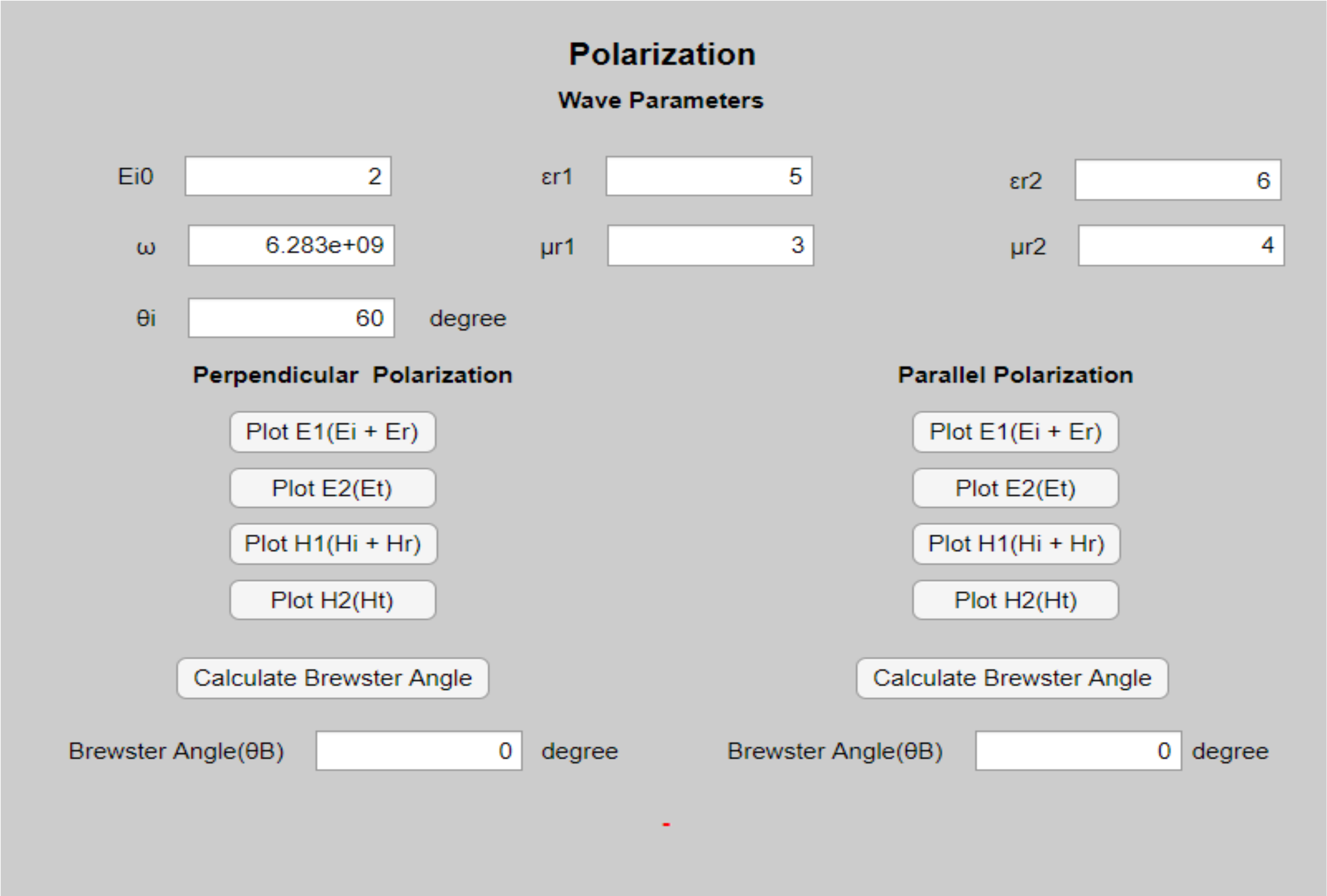
Similarly, the transmitted magnetic field, Ht is

$$H_t = (-\hat{a}_x sin\theta_t + \hat{a}_z cos\theta_t) \, . \, \tau_\perp \frac{E_{i0}}{\eta_2} e^{-j\beta_2(x cos\theta_t + z sin\theta_t)}$$

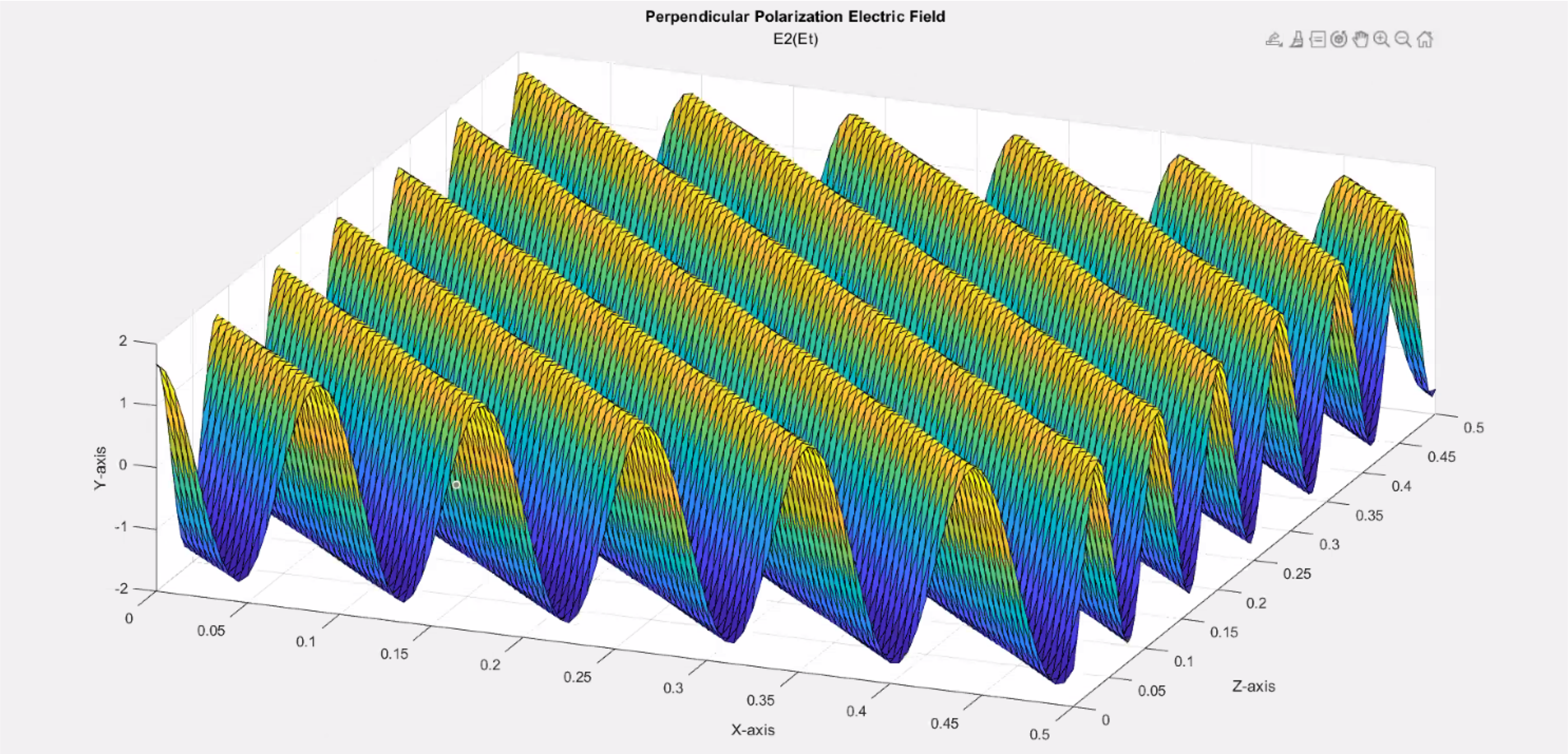
Then the total magnetic field in medium 2, H2 will be (H2=Ht)

$$H_2 = H_t = (-\hat{a}_x sin\theta_t + \hat{a}_z cos\theta_t) \, . \, \tau_\perp \frac{E_{i0}}{\eta_2} e^{-j\beta_2(x cos\theta_t + z sin\theta_t)}$$

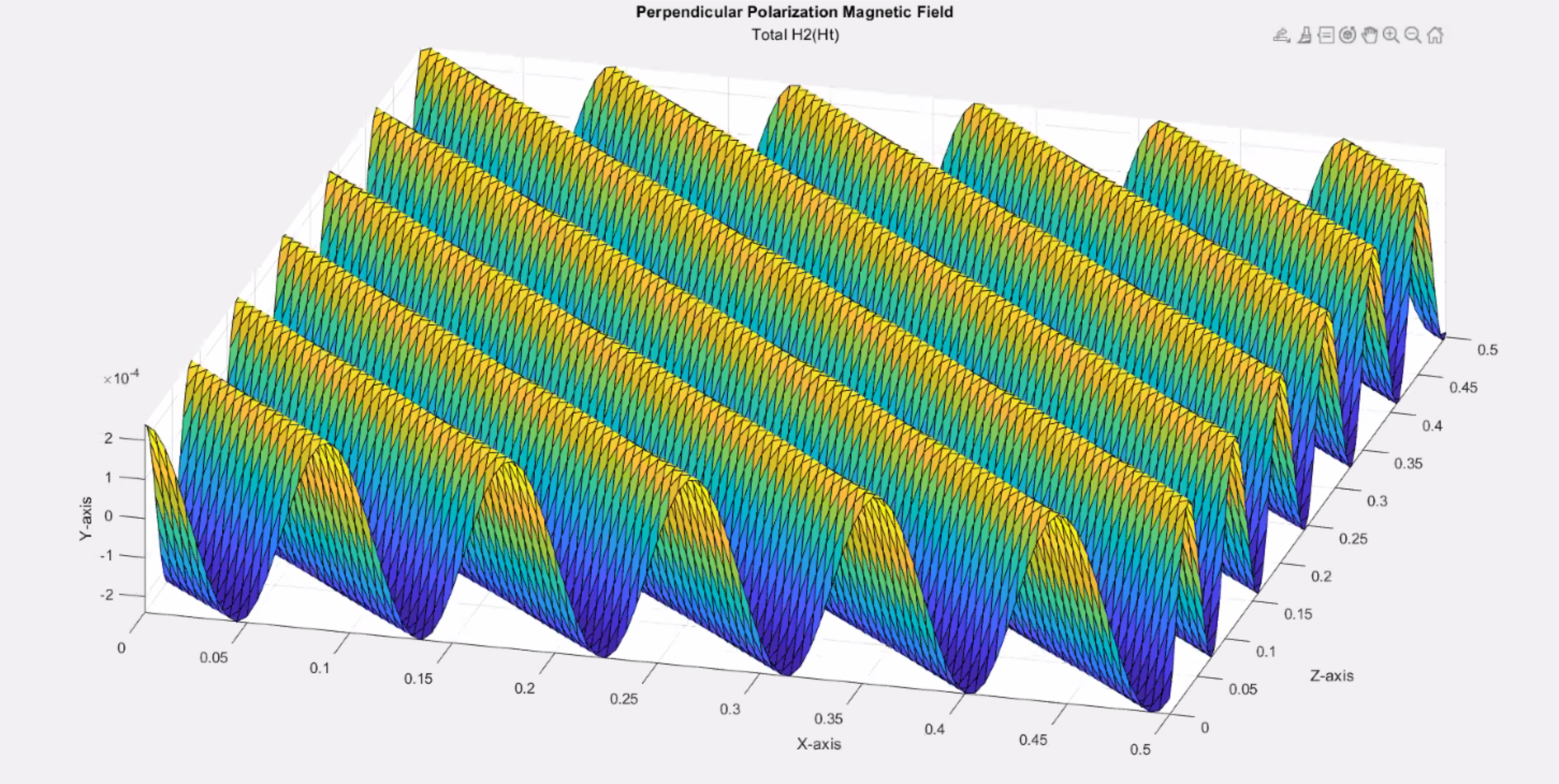
Plotting E2 and H2 in GUI



E2(Et)


Perpendicular Polarization Electric Field
E2(Et)
Y-axis
2
1
0
-1
-2
X-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Z-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

H2(Ht)



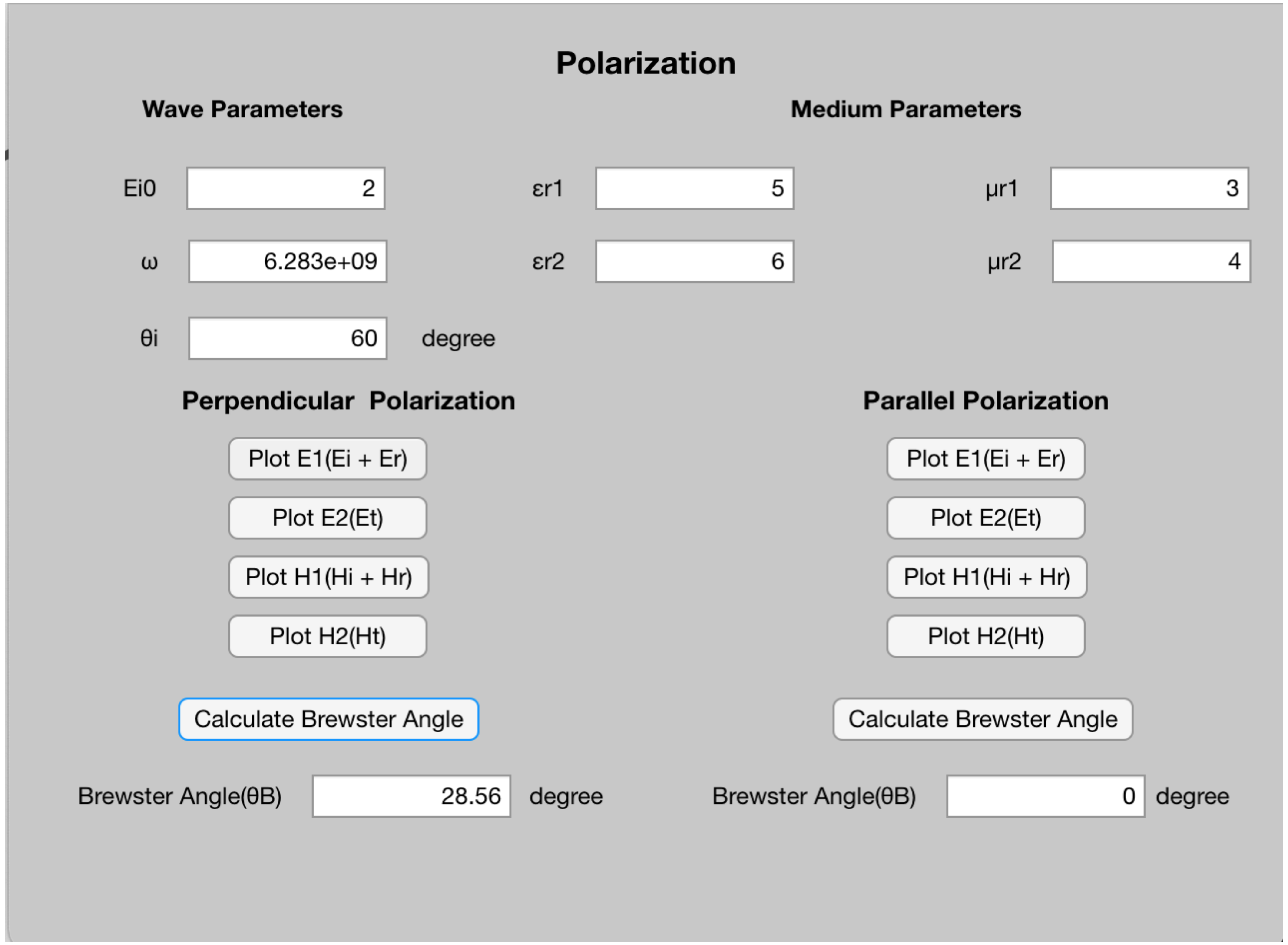
Perpendicular Polarization Magnetic Field
Total H2(Ht)
$\times 10^{-4}$
2
1
0
-1
-2
Y-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
X-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Z-axis

Brewster Angle for Perpendicular polarisation

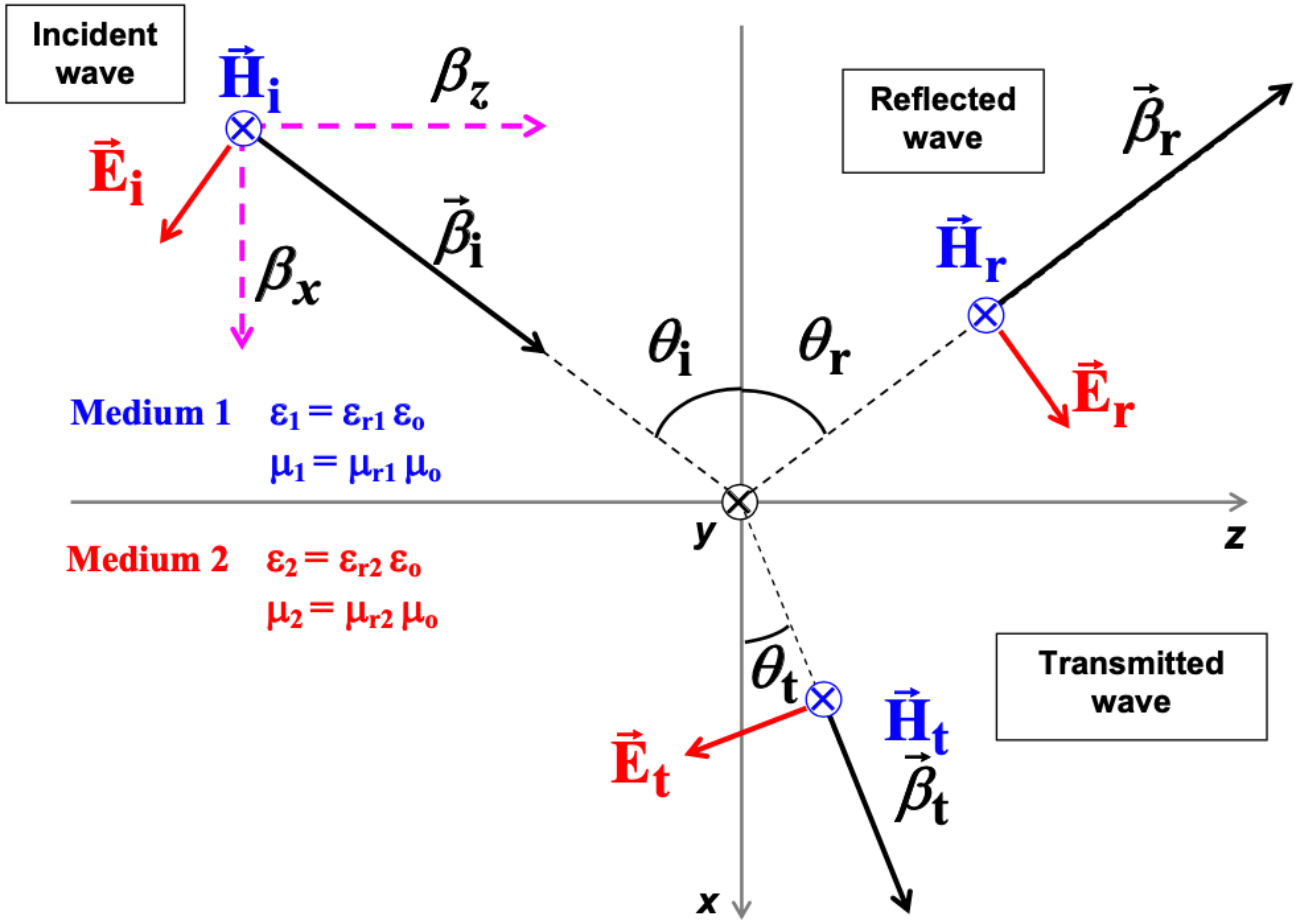
The angle at which incident em wave with an electric field perpendicular to the plane of incidence has a zero reflection coefficient.

$$sin^2\theta_{b_\perp} = \frac{1 - \left(\frac{\eta_1}{\eta_2}\right)^2}{1 - \left(\frac{\mu_1}{\mu_2}\right)^2}$$

Brewster angle calculation in GUI



Case 2 : Parallel polarisation



The magnetic field is perpendicular to the plane of incidence and the electric field is parallel to the plane of incidence.

For the above case, since the incident electric field, Ei is

$$E_i = (\hat{a}_x sin\theta_i - \hat{a}_z cos\theta_i) \, . \, E_{i0} e^{-j\beta_1(xcos\theta_i + zsin\theta_i)}$$

And the reflected electric field, Er is

$$E_r = (\hat{a}_x sin\theta_r + \hat{a}_z cos\theta_r) \, . \, \Gamma_{||} E_{i0} e^{-j\beta_1(-xcos\theta_r + zsin\theta_r)}$$

Then the total electric field in medium 1, E1 will be Ei+Er

$$E_1 = E_i + E_r$$

$$E_1 = (\hat{a}_x sin\theta_i - \hat{a}_z cos\theta_i) \, . \, E_{i0} e^{-j\beta_1(xcos\theta_i + zsin\theta_i)} + (\hat{a}_x sin\theta_r + \hat{a}_z cos\theta_r) \, . \, \Gamma_{||} E_{i0} e^{-j\beta_1(-xcos\theta_r + zsin\theta_r)}$$

Similarly. since the incident magnetic field, Hi is

$$H_i = \hat{a}_y \frac{E_{i0}}{\eta_1} e^{-j\beta_1(xcos\theta_i + zsin\theta_i)}$$

And the reflected magnetic field, Hr is

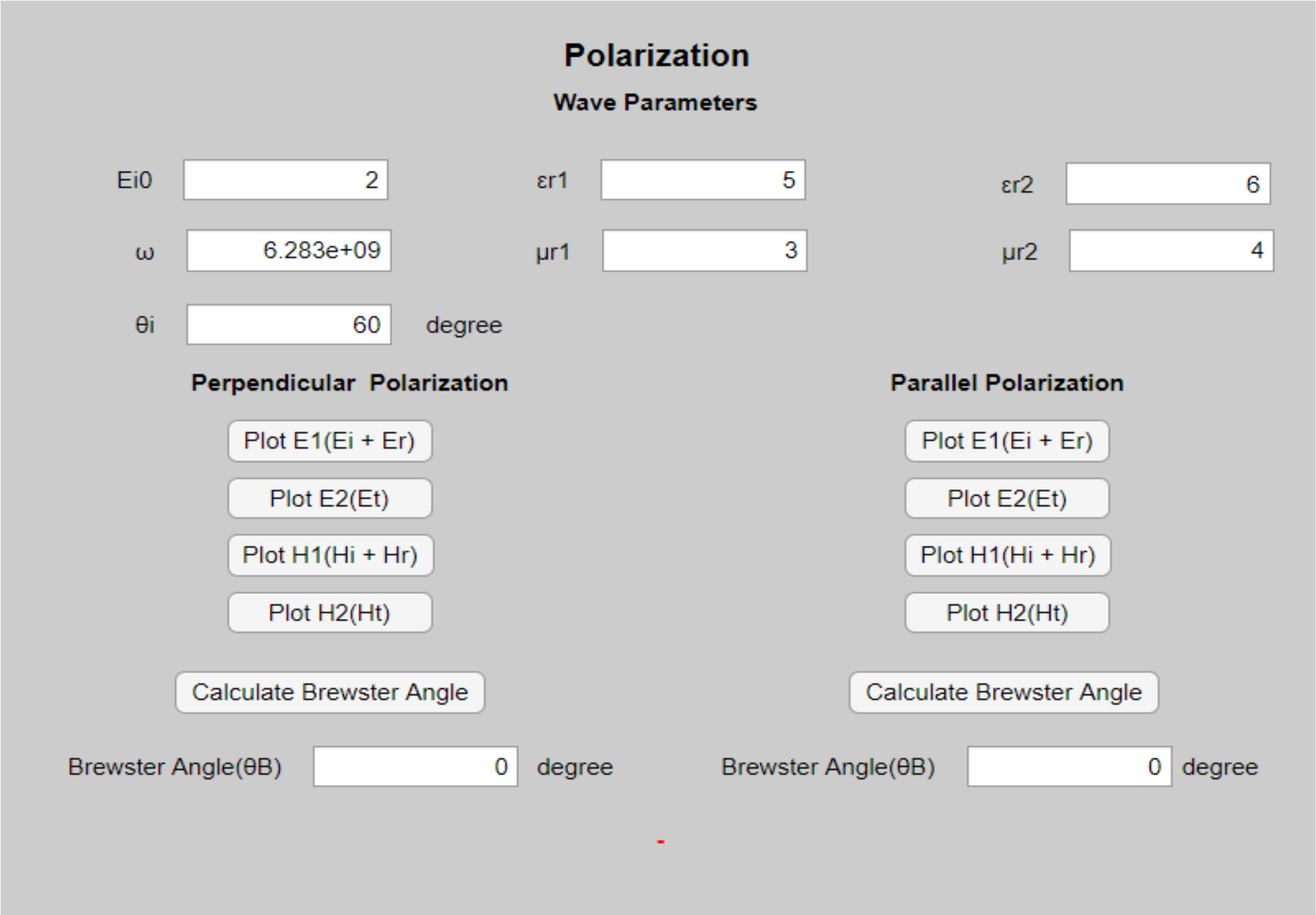
$$H_r = \hat{a}_y \Gamma_{\parallel} \frac{E_{i0}}{\eta_1} e^{-j\beta_1(zsin\theta_i - xcos\theta_i)}$$

Then the total magnetic field in medium 1, H1 will be Hi+Hr

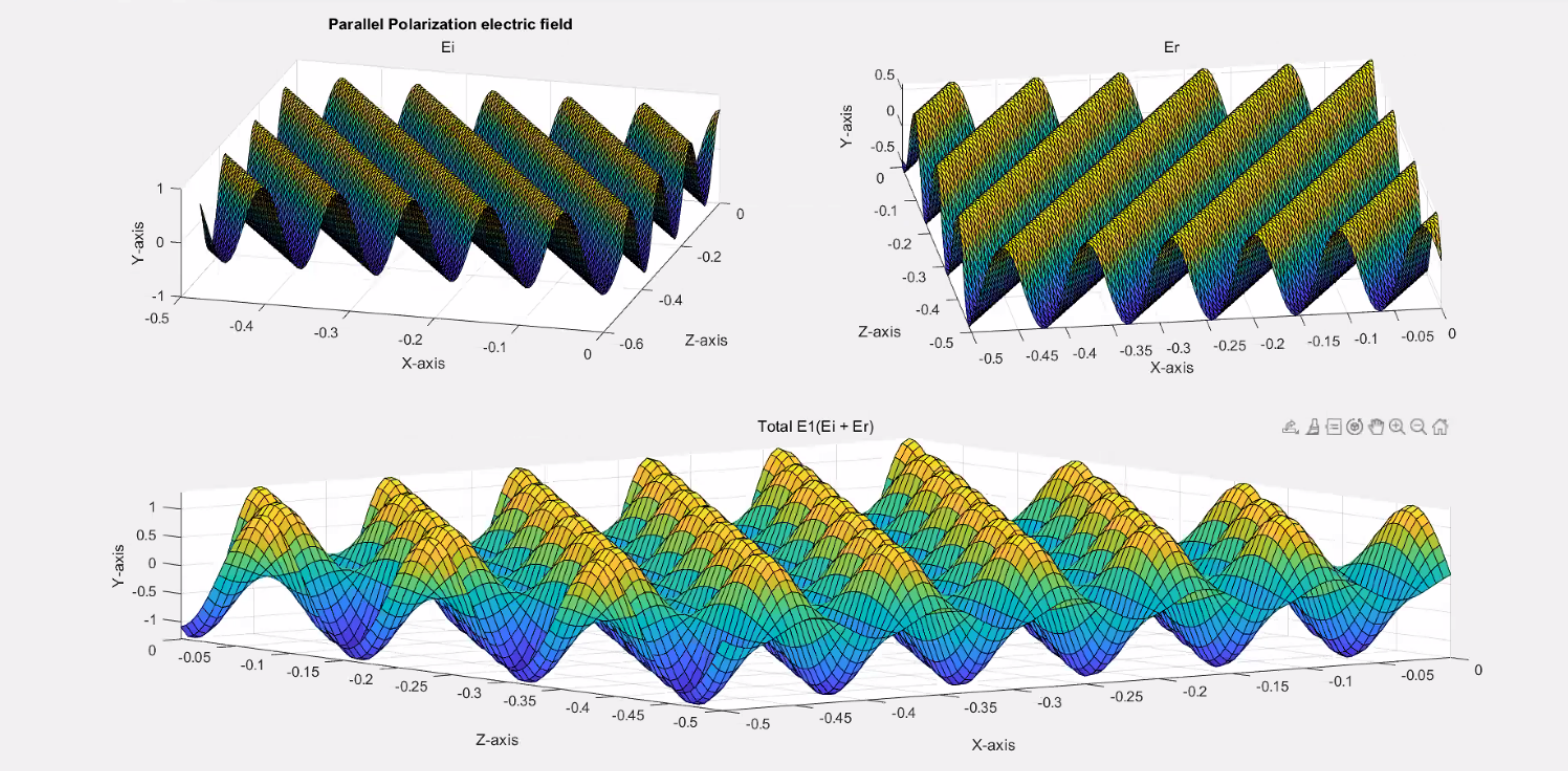
$$H_1 = H_i + H_r$$

$$H_1 = \hat{a}_y \frac{E_{i0}}{\eta_1} e^{-j\beta_1(xcos\theta_i + zsin\theta_i)} + \hat{a}_y \Gamma_{\parallel} \frac{E_{i0}}{\eta_1} e^{-j\beta_1(zsin\theta_i - xcos\theta_i)}$$

Plotting E1 and H1 in GUI

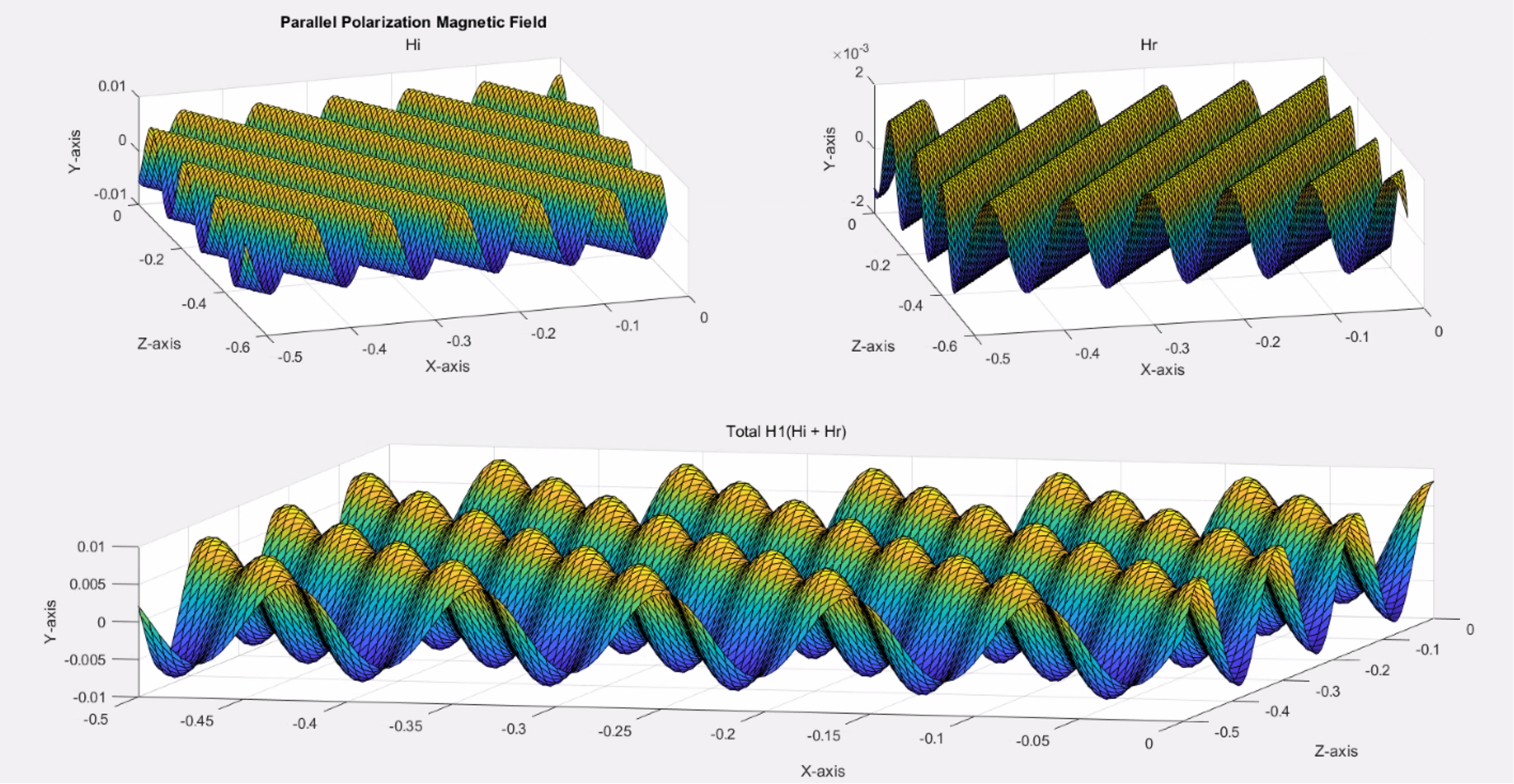


E1(Ei+Er)



Parallel Polarization electric field
Ei
Er
Total E1(Ei + Er)
Y-axis
X-axis
Z-axis

H1(Hi+Hr)


Parallel Polarization Magnetic Field
Hi
Y-axis
Z-axis
X-axis
Hr
$\times 10^{-3}$
Y-axis
Z-axis
X-axis
Total H1(Hi + Hr)
Y-axis
X-axis
Z-axis

Now, in medium 2 the transmitted electric field, Et is

$$E_t = (\hat{a}_x sin\theta_t - \hat{a}_z cos\theta_t) \,.\, \tau_{\|} E_{i0} e^{-j\beta_2(xcos\theta_t + zsin\theta_t)}$$

Then the total electric field in medium 2, E2 will be (E2=Et)

$$E_2 = E_t = (\hat{a}_x sin\theta_t - \hat{a}_z cos\theta_t) \,.\, \tau_{\|} E_{i0} e^{-j\beta_2(xcos\theta_t + zsin\theta_t)}$$

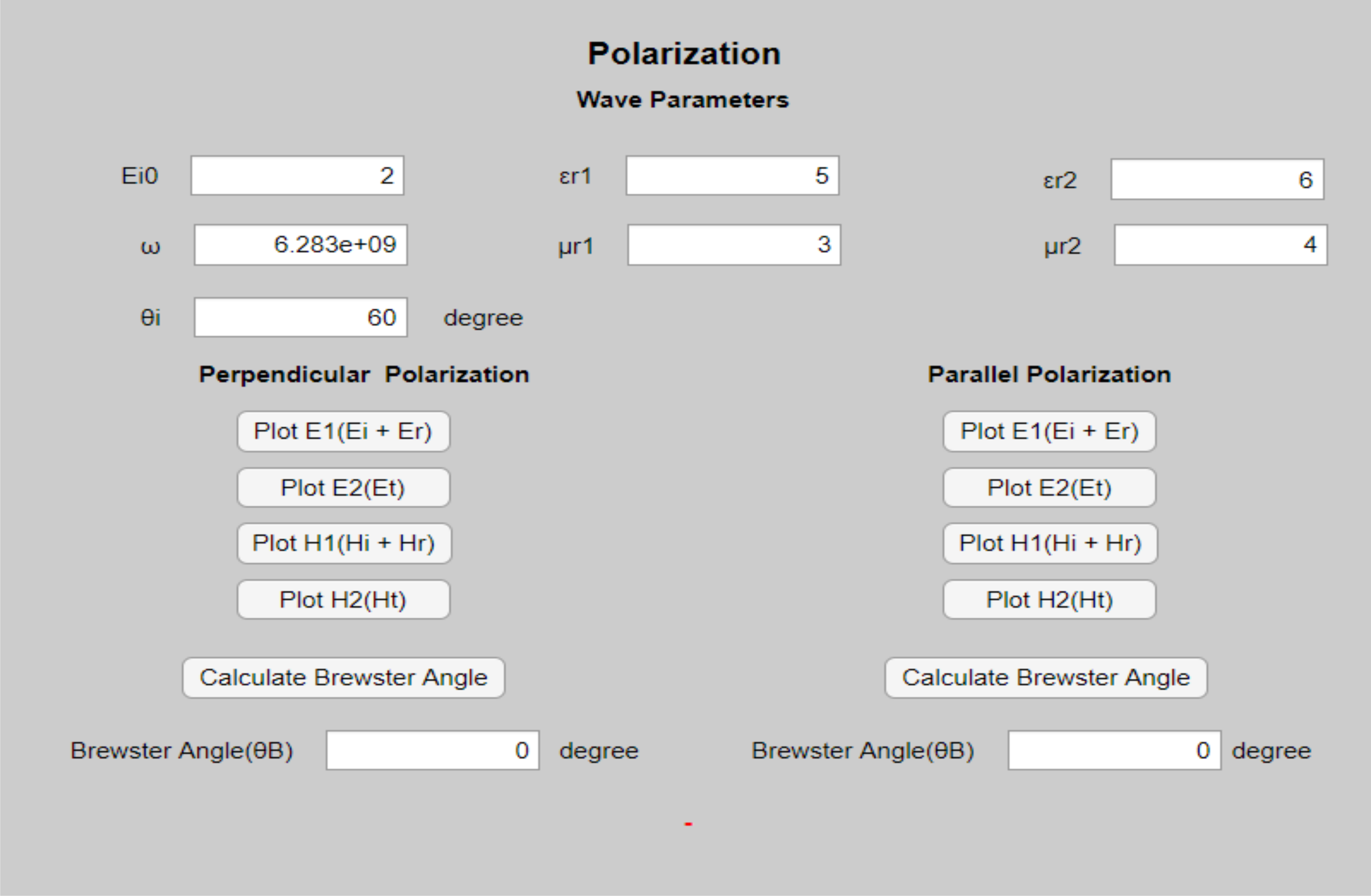
Similarly, the transmitted magnetic field, Ht is

$$H_t = \hat{a}_y \tau_{\|} \frac{E_{i0}}{\eta_2} e^{-j\beta_2(xcos\theta_t + zsin\theta_t)}$$

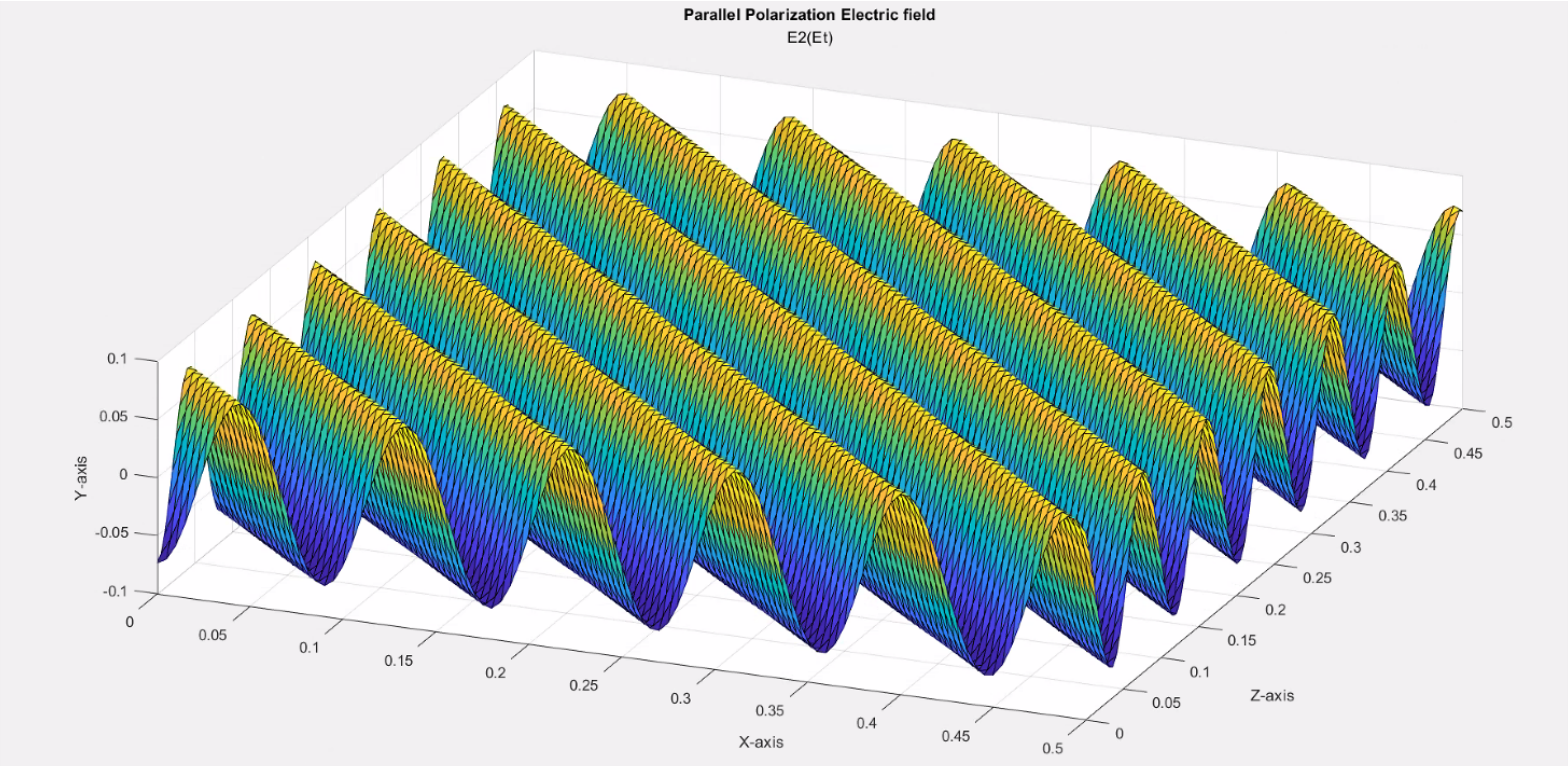
Then the total magnetic field in medium 2, H2 will be (H2=Ht)

$$H_2 = H_t = \hat{a}_y \tau_{\|} \frac{E_{i0}}{\eta_2} e^{-j\beta_2(xcos\theta_t + zsin\theta_t)}$$

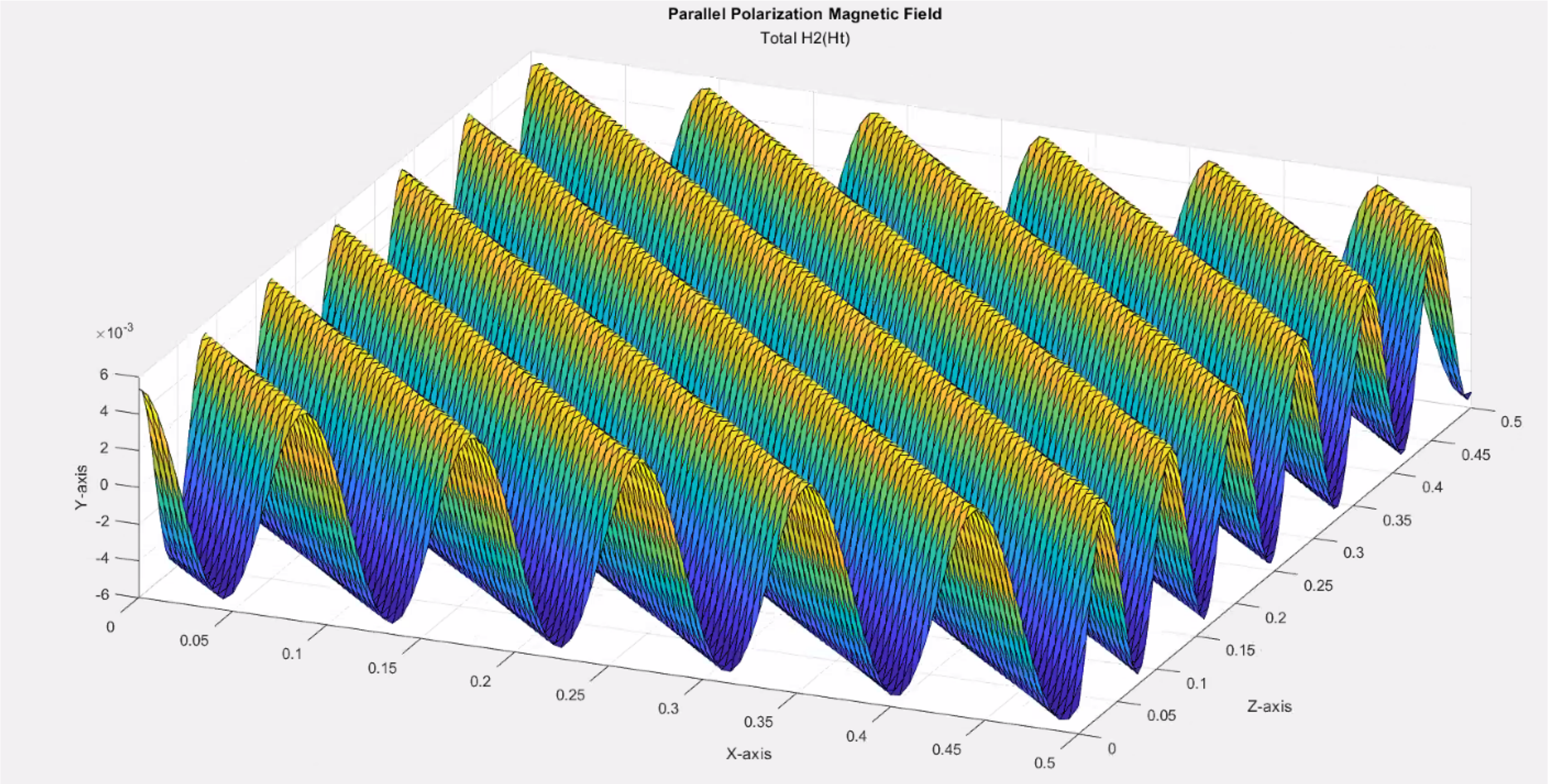
Plotting E2 and H2 in GUI



E2(Et)


Parallel Polarization Electric field
E2(Et)
Y-axis
0.1
0.05
0
-0.05
-0.1
X-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Z-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

H2(Ht)



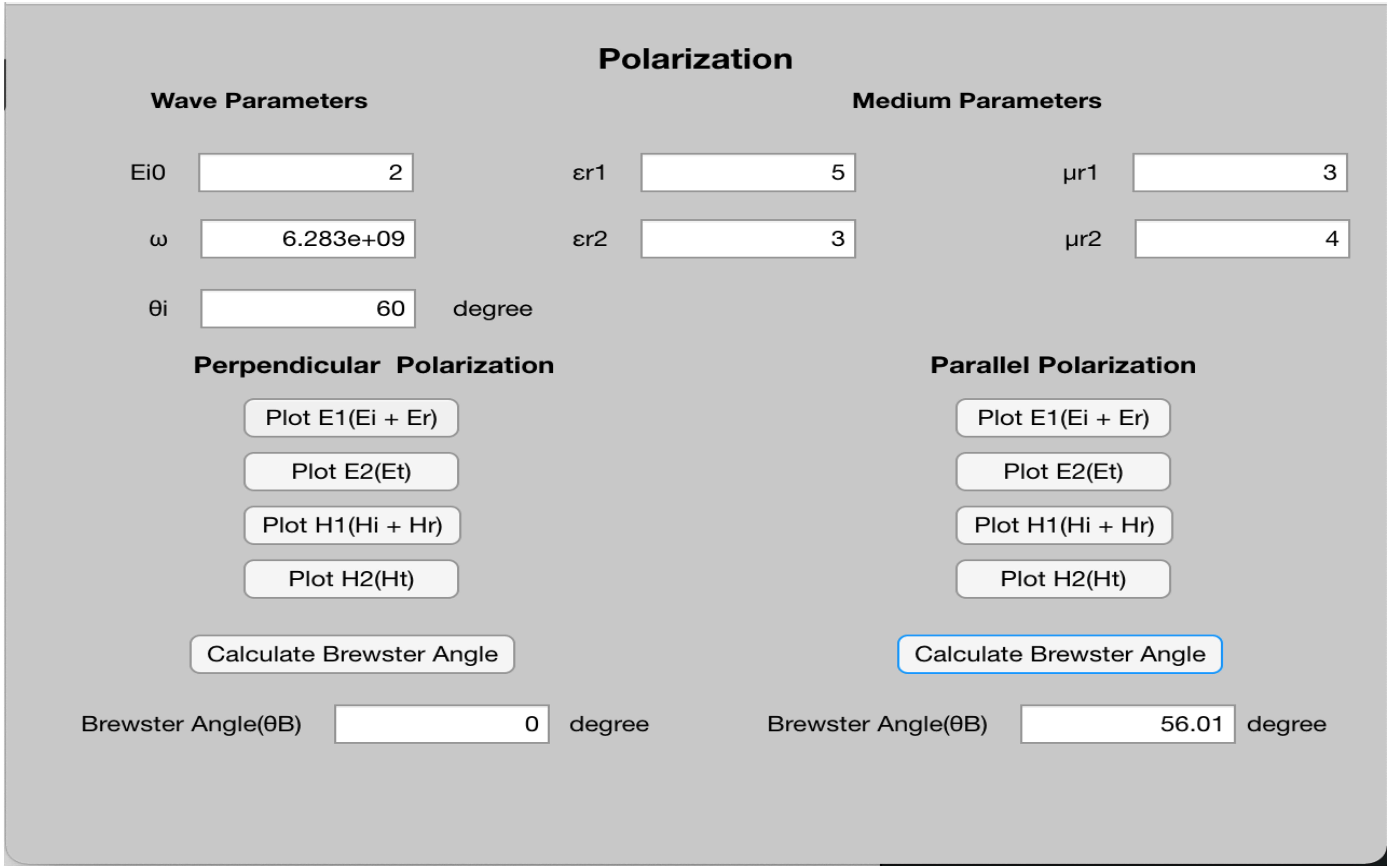
Parallel Polarization Magnetic Field
Total H2(Ht)
×10^-3
6
4
2
0
-2
-4
-6
Y-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
X-axis
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Z-axis

Brewster Angle for Parallel polarization

The angle at which incident light with an electric field parallel to the plane of incidence has a zero reflection coefficient.

$$sin^2\theta_{b_{\|}} = \frac{1-\left(\frac{\eta_2}{\eta_1}\right)^2}{1-\left(\frac{\epsilon_1}{\epsilon_2}\right)^2}$$

Brewster angle calculation in GUI



Thank you