Homework 3 (Polarization) (19-oct-21)

Consider monochromatic light incident on a semi-infinite substrate with complex refractive index $\underset{\sim}{n}$. The Fresnel formulas adequately describe the 's' and 'p' light reflections independently, but now we are interested in describing the polarisation of the whole incident and reflected beams.

For conciseness, for these incident and reflected beams, we will take the X axis normal to the incidence plane (s-direction), Y in the incidence plane (p-direction) and Z pointing along the direction of the beam (so the Z axis is different for the two beams considered here).

Assuming the incident beam has Jones vector $\begin{pmatrix} J_x \\ J_y \end{pmatrix}$, we want to calculate the Jones vector of the reflected beam, using the Fresnel formulas. You have to use the Fresnel formulas with care, since in the present case the Y and Z axis directions are different for the incident and the reflected beams.

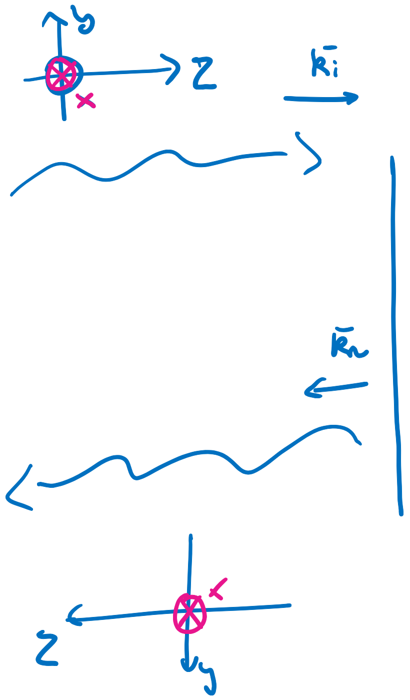
Basing on the scripts presented in the lectures, by adding the required coding,

1) Explain how to calculate the Jones vector for the reflected beam.
2) Idem to find the (ψ, χ) parameters of the reflected beam.
3) Idem to find the ratios of reflected energy (with respect to the incident one).

$J = (1\ i)$

Use your scripts for the case of incident right circular light and for two substrates: $\underset{\sim}{n} = 1.523 + i \times 0.00$ and $\underset{\sim}{n} = 0.45 + i \times 5.47$. Show the results for both substrates and for the incidence angles 50º, 60º and 70º in a Table of values.

Explain all your procedures in a single text file. The explanations about the code of your Matlab (or Python…) 'scripts' has to be included inside the text file, as well as tables of results or figures. Put all the codes of your programs in a separate file.

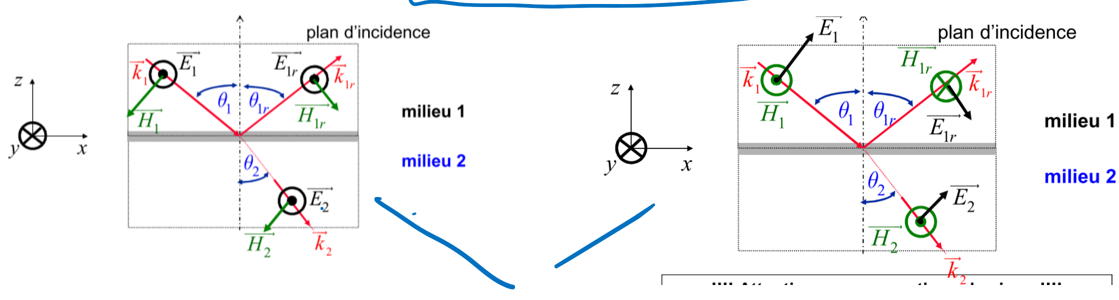


1) input (J_x, J_y) $\downarrow$ output $(J_{x,réfl}\ ;\ J_{y,réfl})$

2) input $(J_{x,réfl}\ ;\ J_{y,réfl})$ $\downarrow$ output (ψ, χ)

conv. de chps >0

ref :

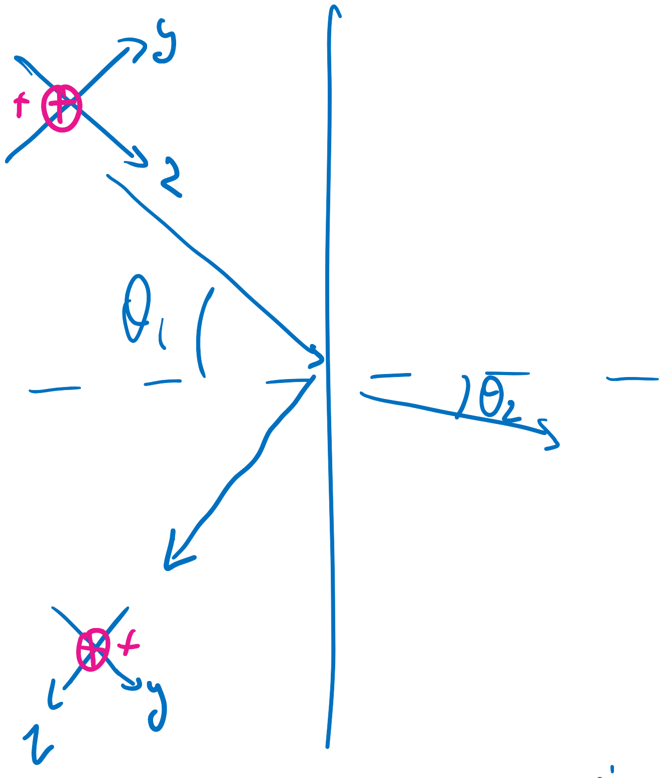


$$E_{1r}^{\parallel} = \underbrace{\frac{n_1 \cos(\theta_2) - n_2 \cos(\theta_1)}{n_2 \cos(\theta_1) + n_1 \cos(\theta_2)}}_{r_{\parallel} = -r_y} \cdot E_1^{\parallel}$$

$$E_{1r}^{\perp} = \underbrace{\frac{n_1 \cos(\theta_1) - n_2 \cos(\theta_2)}{n_1 \cos(\theta_1) + n_2 \cos(\theta_2)}}_{r_{\perp} = r_x} \cdot E_1^{\perp}$$

π d'incidence $= \pi$ feuille

$n_1 = 1 \qquad n_2 = \underset{\sim}{n}$



1

$\sin(\theta_2)\, \underset{\sim}{n} = \sin(\theta_1)$

$\theta_2 = \text{Arcsin}\left(\frac{\sin(\theta_1)}{\underset{\sim}{n}}\right)$

$$J_{x,ref} = \underbrace{\frac{\cos\theta_1 - \underset{\sim}{n} \cos\theta_2}{\cos\theta_1 + \underset{\sim}{n} \cos\theta_2}}_{r_x} \cdot J_x$$

$$J_{y,ref} = - \underbrace{\frac{\cos\theta_2 - \underset{\sim}{n} \cos\theta_1}{\underset{\sim}{n} \cos\theta_1 + \cos\theta_2}}_{r_y} \cdot J_y$$

(2)

$$\tan 2\psi = \frac{2r}{1-r^2}\cos\phi, \quad r = \frac{a_y}{a_x} = \frac{E_{0y}}{E_{0x}},$$

$$\sin 2\chi = \frac{2r}{1-r^2}\sin\phi, \quad \phi = \phi_y - \phi_x$$

→ On applique ça au $\vec{J}$ sorti de Jeb (1)

(3) Ratio of reflected Energy $= \alpha$

$$\alpha = \frac{I_r}{I_i} = \frac{|J_{x,ref}|^2 + |J_{y,ref}|^2}{|J_x|^2 + |J_y|^2}$$

Intensité dans milieu de refraction Index n

$$\frac{|E_{0x}|^2 + |E_{0y}|^2}{2\eta}$$