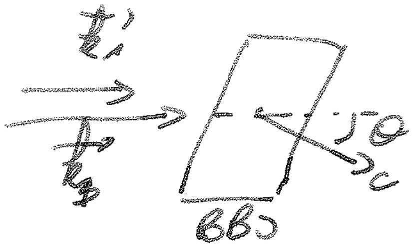
CORRECTION

EXERCICE : Amplification paramétrique dans un BBO.

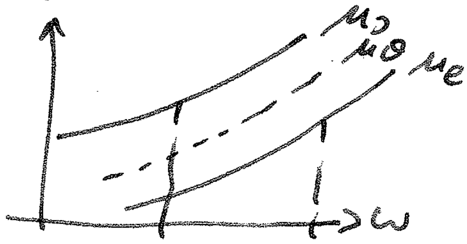



1- Questions de cours voir le cours.

2- $\omega_3 = \omega_1 + \omega_2 \Rightarrow \dfrac{1}{\lambda_2} = \dfrac{1}{\lambda_3} - \dfrac{1}{\lambda_1}$

$\lambda_2 = 633,2$ nm.

3- accord de phase de type I - BBO cristal uniaxe négatif $\Rightarrow n_e < n_o$




$\Rightarrow$ onde à $\omega_3$ polarisée extraordinaire

$\Rightarrow$ ondes à $\omega_1 / \omega_2$ ordinaires

4- accord de phase colinéaire

$$\vec{k}_3 = \vec{k}_1 + \vec{k}_2 \Rightarrow n_\theta(\omega_3)\frac{\omega_3}{c} = \frac{n_o(\omega_1)\omega_1}{c} + \frac{n_o(\omega_2)\omega_2}{c}$$

5- $$n_\theta(\omega_3) = \frac{n_o(\omega_1)\omega_1 + n_o(\omega_2)\omega_2}{\omega_3}$$

$$\boxed{n_\theta(\lambda_3) = \left(\frac{n_o(\lambda_1)}{\lambda_1} + \frac{n_o(\lambda_2)}{\lambda_2}\right)\lambda_3}$$

A.N : $n_\theta(\lambda_3) = 1,663930$

6- $$\frac{1}{n_\theta^2} = \cos^2\theta\left[\frac{1}{n_o^2} - \frac{1}{n_e^2}\right] + \frac{1}{n_e^2}$$

$$\Rightarrow \cos^2\theta = \left[\frac{1}{n_\theta^2} - \frac{1}{n_e^2}\right]\frac{n_e^2 n_o^2}{n_e^2 - n_o^2}$$

$$\cos^2\theta = \frac{n_o^2}{n_\theta^2}\,\frac{n_e^2 - n_\theta^2}{n_e^2 - n_o^2} \simeq \frac{n_o^2}{n_\theta^2}\,\frac{n_e - n_\theta}{n_e - n_o}$$

$$\Rightarrow \boxed{\cos\theta = \frac{n_o}{n_\theta}\sqrt{\frac{n_e-n_\theta}{n_e-n_o}}}$$ A.N.: $\theta = 32{,}35°$

(indices à $\omega_3$)

7- (a) $\chi^{(2)}_{eff} = 2\vec{e_o}\cdot\underline{\underline{\chi}}^{(2)}\vec{e_o}\vec{e_o}$

Démo: $\vec{E}(\omega_3) = \vec{e_\theta} A_3 e^{ik_3 z}$, $\vec{E}(\omega_2) = \vec{e_o} A_2 e^{ik_2 z}$

$$\vec{P_{NL}}(\omega_1) = \varepsilon_0 \underline{\underline{\chi}}^{(2)}(\omega_1;\omega_3,-\omega_2)\vec{e_\theta}\vec{e_o} A_3 A_2^* e^{i(k_3-k_2)z}$$
$$+\varepsilon_0 \underline{\underline{\chi}}^{(2)}(\omega_1;-\omega_2,\omega_3)\vec{e_o}\vec{e_\theta} A_2^* A_3 e^{i(k_3-k_2)z}$$

symétrie de Kleinman: $\underline{\underline{\chi}}^{(2)}(\omega_1;\omega_3,-\omega_2) = \underline{\underline{\chi}}(\omega_1;-\omega_2,\omega_3)$

$$\Rightarrow \vec{P_{NL}}(\omega_1) = 2\varepsilon_0 \underline{\underline{\chi}}^{(2)}(\omega_1;\omega_3,-\omega_2)\vec{e_\theta}\vec{e_o} A_3 A_2^* e^{i(k_3-k_2)z}$$

$$\Rightarrow \boxed{\chi^{(2)}_{eff}(\omega_1) = 2\vec{e_o}\cdot\underline{\underline{\chi}}^{(2)}\vec{e_\theta}\vec{e_o} = \chi^{(2)}_{eff}(\omega_2)}$$

(b) $d_{22} = -d_{21} = -d_{16} \Leftrightarrow \chi^{(2)}_{222} = -\chi^{(2)}_{211} = -\chi^{(2)}_{112}$

$d_{15} = d_{31} = d_{24} = d_{32} \Leftrightarrow \chi^{(2)}_{113} = \chi^{(2)}_{311} = \chi^{(2)}_{223} = \chi^{(2)}_{322}$

$$\chi^{(2)}_{eff} = 2\vec{e_o}\cdot\left|\begin{array}{l} -\underbrace{\chi^{(2)}_{112}}_{-d_{22}}\sin^2\varphi\cos\theta + \underbrace{\chi^{(2)}_{121}}_{-d_{22}}\cos^2\varphi\cos\theta + \chi^{(2)}_{113}\sin\varphi\sin\theta + \chi^{(2)}_{131}\times 0 \\ -\underbrace{\chi^{(2)}_{211}}_{-d_{22}}\sin\varphi\cos\varphi\cos\theta + \underbrace{\chi^{(2)}_{222}}_{d_{22}}\cos\varphi\sin\varphi\cos\theta - \chi^{(2)}_{223}\cos\varphi\sin\theta + \chi^{(2)}_{232}\times 0 \\ \underline{\qquad} \end{array}\right.$$

inutile de calculer puisque $\vec{e_o}\cdot\vec{z} = 0$.

$$\chi^{(2)}_{eff} = \vec{e_o}\cdot\left|\begin{array}{l} d_{22}\cos\theta[\sin^2\varphi-\cos^2\varphi] + d_{31}\sin\varphi\sin\theta \\ d_{22}\sin 2\varphi\cos\theta - d_{31}\cos\varphi\sin\theta \\ \underline{\qquad} \end{array}\right.$$

$$\Rightarrow \chi^{(2)}_{eff} = d_{22}\cos\theta\sin\varphi[\sin^2\varphi-\cos^2\varphi] + d_{31}\sin^2\varphi\sin\theta$$
$$- d_{22}\cos\varphi\sin 2\varphi\cos\theta + d_{31}\cos^2\varphi\sin\theta$$

$$\chi^{(2)}_{eff} = d_{31} \sin\theta - d_{22} \cos\theta \left[ \sin\varphi \cos 2\varphi + \cos\varphi \sin 2\varphi \right]$$

$$\boxed{\chi^{(2)}_{eff} = d_{31} \sin\theta - d_{22} \cos\theta \sin 3\varphi}$$

(c) $\chi^{(2)}_{eff}$ est $\underline{\text{max}}$ pour $\sin 3\varphi = -1 \Rightarrow 3\varphi = -\frac{\pi}{2} \; [2\pi]$

$\Rightarrow \varphi = -\frac{\pi}{6} \; \left[\frac{2\pi}{3}\right]$.

(b) $\chi^{(2)}_{eff\,max} = 1{,}996$ pm/V

$\theta = 32{,}36°$ et $\varphi = -\frac{\pi}{6}$

8_ Calcul du gain paramétrique.

(a) $A_1(z) = A e^{\gamma_0 z} + B e^{-\gamma_0 z}$ $\qquad A_1(z=0) = A_{10} = A + B$

$\frac{dA_1}{dz} = \gamma_0 A e^{\gamma_0 z} - B \gamma_0 e^{-\gamma_0 z}$ $\qquad \left.\frac{dA_1}{dz}\right|_{z=0} = 0 = A - B$

$\Rightarrow \boxed{A = B}$

$\Rightarrow \boxed{A_1(z) = A_1(0)\, \mathrm{ch}\, \gamma_0 z}$

(b) $I_3 = \dfrac{E_3}{\tau \frac{\pi D^2}{4}}$ avec $E_3$ = énergie de impulsion, $\tau$ = durée

$\underline{\text{A.N:}}$ $I_3 = 3819$ MW/cm$^2$

(c) $G = \left| \mathrm{ch}(\gamma_0 L) \right|^2$ $\qquad \underline{\text{A.N:}}$ $\boxed{G = 21}$

(e) $E_{in} = 1\,\mu J \Rightarrow E_{out} = 21\,\mu J$

(f)